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CONTENTS.

VOLUME I.

GENERAL TRANSACTIONS.

ABSTRACTS OF PAPERS.

JOHN S. NEWBERRY.

JOHN K. REES.

ISRAEL C. RUSSELL.

JAMES H. STEBBINS, JR.

W. LE CONTE STEVENS.

JOHN J. STEVENSON.

ROBERT H. THURSTON.

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F. G. WEICHMANN.

PAPERS WITHOUT ABSTRACTS.

COMMITTEE REPORTS.

GENERAL INDEX.

For all names in Botany and Zoology, see Index of Nomenclature, following the General Index.

For full titles of papers in this volume, and names of their authors, see Table of Contents.

INDEX OF NOMENCLATURE.

TRANSACTIONS

OF THE

NEW YORK ACADEMY OF SCIENCES.

October 3, 1881.

REGULAR BUSINESS MEETING.

Vice-President, Dr. B. N. MARTIN, in the chair.

Twenty-five members present.

After the transaction of business the members were invited, in accordance with the usual custom at the first meeting of the season, to present notes and observations recorded during the summer, and responses were made by Mrs. E. A. SMITH, Prof. C. A. SEELEY, and others.

Mr. W. L. CHAMBERLAIN referred to the gold deposits recently opened in Fulton and Saratoga counties, N. Y. The ore consists of auriferous pyrites and is contained in the gneiss of the foothills of the Adirondacks.

Remarks were made by a member, on a visit to the sandstone quarries at Portland, Conn.; by Mr. TODD, on a peculiar atmospheric phenomenon, a vaporous band stretching across the sky, apparently not auroral, observed in the Adirondacks; and by Dr. MARTIN, on a remarkable atmospheric coloration, luminous brilliance of the clouds, etc., observed last month at Saratoga, in the early morning, attributing it to an abundance of a smoky fog produced by the recent forest fires, and calling attention to the fact that this phenomenon has been noticed only in the territory east of the meridian of Saratoga.

Mrs. P. HANAFORD described the same appearances as seen during the "Yellow Day," Sept. 6, near Boston, and also on Nantucket; another member, as seen in the Genesee valley, explaining that the strong west and northwest winds prevailing at the time had wafted high in the air vast volumes of smoke derived from the abundant forest fires throughout Western N. Y.; Messrs. TODD, CHAMBERLAIN, and others, describing the electric brilliance of the gas-lights, the strange modification of the green color of foliage, the absence of smoky odor, etc., as observed at Great Barrington, Mass., and in less degree in New York city; Mr. N. L. BRITTON, on the same facts as observed several miles out at sea, off Fire Island and Montauk Point, Long Island, N. Y.; Prof. D. S. MARTIN, as observed between Saratoga and Catskill, N. Y.; and Prof. C. A. SEELEY, calling attention to the extremely attenuated character of the carbon particles, produced by their long transportation from distant localities.

Mr. GEO. F. KUNZ mentioned that Mt. Mica, at Paris, Maine, the locality so famous for colored tourmalines for the last fifty years, had been purchased by a mining company and was being worked for cassiterite, mica and tourmaline, principally through the efforts of Dr. A. C. Hamlin of Bangor, Maine.

Dr. Hamlin has the finest known collection of American tourmalines, and he recently reported the discovery of a crystal, three inches long and one-half inch thick, a transparent gem of a beautiful blue-green color. This was taken from the new mine, and many more remarkable specimens may be expected as the work advances.

Mr. Kunz said that during the last year a German agate-hunter returned to his native country after 20 years collecting in Brazil, taking with him a large suite of fine colored tourmalines, some five inches long and not more than one-eighth of an inch thick, transparent, and of a green color; also many fine green crystals with red, yellow, white, and other colored centres, many of these equalling for variety of color anything yet found, most of which will cut as gems. There is also in this lot one exceptionally fine green crystal over one inch square. This collector brought with him also at least 1000 kilos of transparent yellow spodumene, the same as that described by A. Pisani, of Paris, some eighteen months ago, and is dissimilar only in color to the new variety of spodumene found at Stony Point, North Carolina, described in the February number of the *American Journal of Science* for 1881, by Dr. J. Lawrence Smith, as Hiddenite. Some of the specimens which he brought will cut as fine yellow gems. All these were found in the Minas Geraes district. Recently a new locality for chrysoberyls has been found in Ceylon, where they occur of gem value in an unusual variety of colors, from yellow to brown, and from brown to green. The last color is the variety known as Alexandrite. This gem has heretofore been found but of very inferior size and color, but here it occurs of remarkable size, having in one case afforded a gem weighing 26 kts. They are a beautiful green color by day and a columbine red, or brownish red, by night. The chrysoberyl cat's eye is found here of the same color, and possessing the same dichroic property as the Alexandrite, viz., changing color, from green to red, and hence might very properly be called an Alexandrite cat's eye. Many of the chrysoberyls are erroneously called and sold as a variety of sapphire.

October 10, 1881.

SECTION OF CHEMISTRY.

Vice-president, Dr. B. N. MARTIN, in the Chair.

Nineteen members present.

A paper was read by Mr. JAMES H. STEBBINS, Jr., of which the following is an abstract:

ON SOME NEW SALTS OF THYMOLE SULPHO-ACID, AND SOME NEW FACTS CONCERNING THE SAME.

60 grms. thymole were dissolved in 50 grms. 66° sulphuric, at a temperature of 100° C. The pink crystalline mass so obtained was dissolved in water, and converted into the lime salt.

Calcium Salt.—This salt crystallizes with two molecules of water, in rhombic plates, and shows under the polariscope a beautiful effect of circular polarized light.

Formula.

$$a\ (C_6\ H_2\ (C\ H_3)\ (C_3\ H_7)\ (O\ H)\ S\ O_3)_2\ Ca + 2H_2\ O.$$

a. Calcium salt of alpha thymole sulpho-acid.

Ammonium Salt.—This salt was obtained by decomposing the lime salt, with ammonic carbonate. It crystallizes in white rhombic plates, with 2 mols. of water.

Formula.

$$a\ C_6\ H_2\ (C\ H_3)\ (C_3\ H_7)\ (N\ H_4\ S\ O_3)\ a\ H + 2\ H_2\ O.$$

The sodium salt has likewise been obtained, and will be described in a subsequent paper.

Remarks were made by Mr. JAMES D. WARNER on the nature of the corona of the Sun, etc. Mr. STEBBINS reported the yellow coloration of the atmosphere in September at the Thousand Islands in the St. Lawrence.

October 17, 1881.

SECTION OF GEOLOGY AND MINERALOGY.

The President, Dr. J. S. NEWBERRY, in the Chair.

Fifty-one persons present.

Dr. NEWBERRY exhibited specimens of native lead and oxide of lead from a mine in the Wood river country, Idaho, crystallized gray copper, and fine crystallized rhodochrosite from the Ulay mines, Southwest Colorado.

Dr. T. EGLESTON pronounced the crystals of Rhodochrosite the finest he had ever seen, and probably the finest specimens ever yet found.

He stated to the Academy that since its adjournment in June he had made the discovery of tellurium in certain copper products from Colorado. The sample examined had been found to work unsatisfactorily and was supposed to contain arsenic and antimony, as the pig yielded dense white fumes in the furnace. After a careful examination no arsenic nor antimony was found, but nearly one half per cent of tellurium. The fumes poisoned the furnace, and the copper manufactured cracked in the rolls, was useless except for brass of poor quality, but was quite suitable for the manufacture of cupric sulphate. A number of ounces to the ton of silver and gold were found in the same copper, but too little to make a metallurgical separation possible.

Dr. Egleston also announced that after making a long series of examinations on the presence of silver in Lake and other brands of commercial copper, he had come to the conclusion that the silver was very unequally distributed in it; as assays taken fifteen minutes apart from several different charges, during the last two hours of the process while ladling, show the quantity to vary as much as eight or ten ounces in the different assays.

Dr. J. S. NEWBERRY remarked on:

GEOLOGICAL FACTS RECENTLY OBSERVED IN MONTANA, IDAHO, UTAH AND COLORADO.

Idaho and Montana.—The famous placers at Helena and Virginia, which have yielded thirty millions of dollars, are now exhausted, but vein-mining is in successful progress and yielding rich results at Butte, at the Alice, Lexington, Copper Bell, and other mines. These are true fissure veins, traversing a granite formation, and the speaker predicted their abundant yield of silver and copper twenty years hence. These territories have been simply crossed by two government expeditions and their resources have not been at all studied. It is the coming mining region, more discoveries of promising mines having been recently made here than in any other portion of the country. On the east of the mountains in Montana and Wyoming lies a fine agricultural country and excellent stock range, the herds ranging freely throughout the winters, in spite of their severity, with little loss, and grazing upon a native bunch-grass (*Festuca scabrella*) and the buffalo grass (*Buchloe dactyloïdes*). The climate is salubrious, the country very beautiful in many parts and very promising for emigration. In the adjacent Rocky Mountains range there are also many mining opportunities.

The remarkable lava plain, 400 miles long by 75 miles wide, in Central Idaho, was then described. Snake River, one of the chief tributaries of the Columbia, flows along its southern border for several hundred miles; its northern tributaries sinking under the lava sheet and flowing in subterranean channels 50 or 60 miles long. The rock is a basalt said to contain every where a small quantity of gold and silver. It is generally covered with an impalpable soil that produces a dust excessively annoying to the traveler, and sustains a general growth of sage brush. In places, however, the rock is bare and looks like a congealed stormy sea. Three buttes are set on the surface of this lava plain, and each has probably been a local volcanic vent; but it is probable that most of this eruptive material has been an overflow from great fissures of which the position is not indicated on the surface. Snake River crosses a portion of this plain in a cañon, at the head of which are the great Shoshone Falls, 208 feet in vertical altitude.

An alluvial plain borders Snake River for 200 miles, abounding in black sand which contains much gold. This is, however, extremely fine, having been transported a long distance from its place of origin, and therefore difficult of separation. New and promising methods and machines are about to be tried in the exploitation of these extensive deposits. A wide mountain belt extends from the north side of the lava plain to and beyond the British line, and is apparently a good mining country throughout. Already a great number of productive and promising mines are opened in the southern portion of this belt. In the Wood River district the veins are not large, but numerous, regular and persistent, and the ore of high grade—mostly argentiferous galena, carrying $100 to $500 in silver to the ton. Near Challis, further north, is the celebrated Ram's Horn mine, located on a true fissure vein, generally not more than five feet wide, but continuous for more than five miles. The wall rocks are slate, the veinstone siderite (carbonate of iron), the ore gray and yellow copper, yielding $100 to $1200 in silver to the ton. A few miles west of Challis is the mining town of Bonanza, where are located the celebrated Charles Dickens and Custer mines, carrying both silver and gold. Still further West in the Saw Tooth range, a high and very picturesque mountain chain running north and south, recent discoveries of valuable mines have been made. From this district north to the Canadian line, a broad mountain belt extends over northern Idaho and northwestern Montana, a country which abounds in veins of silver, copper and gold. Among the mines now worked in this region the most celebrated is the Drum Lomond, in Montana. It is opened on a large vein of rich quartz, and is owned by an old miner who cannot read, but who is said to have refused a million of dollars for the property. It is probably worth much more than this.

Most of the mountainous districts of Idaho and Montana are covered with coniferous forests, consisting of the Douglas spruce and the northern nut pine, *Pinus flexilis*. The smaller plants form an Alpine flora of much interest, including many beautiful flowering species;

perhaps the most striking being *Bryanthus*, which has a fine fir-like foliage and clusters of beautiful purple flowers. It belongs to the Heath family, and closely resembles the heather of Scotland.

The streams of this region are clear, cold, and rapid, and abound in fish, chiefly of the salmon family, and these have given the name to Salmon River, the principal water course.

Two species of salmon were running up the Salmon River, one the large Quinnat or Chinook salmon, comparatively rare, and the other the "red fish" (*Oncorhynchus nerka*). This is a small salmon, 15 to 18 inches in length, and weighing 3 to 5 pounds. As seen in their migration their bodies are brick red to purple in color, the heads dark or light green ; they were then going up to their spawning ground, Redfish Lake, one of a half-dozen of small lakes on the headwaters of the Columbia, which are the special breeding-places of this interesting fish. Coming all the way from their abode in the ocean, led by an infallible but inscrutable instinct, they push on night and day till they reach their remote birthplaces in these little lakes far up in the mountains and 1000 miles from their starting point. Here they accomplish apparently the great object of their lives, the reproduction of the species, by depositing the spawn in the shallows of the rivulets which fall into the lake.

The always attractive coloring of the fish during this nuptial season becomes greatly heightened ; the body assumes a brilliant, almost luminous red, as bright as that of the gold fish, and where numbers are dashing through the water, literally in a blaze of excitement, they produce an exhibition that is strikingly novel and interesting.

When the spawning season is over they probably do not return, as none are seen descending the rivers. The young fish start on their migration to the ocean while yet very small, and within the first year of their lives, remaining away it is supposed some three or four years, during which they acquire their full growth when they return to die where they were born.

An active industry has grown up in the capture of the red fish in their annual migrations, but it is pushed with so much energy and unsparing cupidity that their numbers are rapidly diminishing and the species will apparently be soon extirpated in these waters unless protected by legal enactment.

A branch of the Union Pacific Railroad is being constructed from Granger, Wyoming, to the mouth of the Columbia. On this a large amount of traffic is expected, as it will link together many settlements having a considerable resident population and traverse in different portions of the route rich agricultural and mining districts.

Dr. Newberry then briefly described a small but remarkably rich placer gold deposit he visited on the west flank of Mount Wheeler, the highest mountain in Nevada, and mentioned the discovery of an outcrop of lower silurian rocks full of fossils, including several new trilobites, discovered by him in Southwestern Utah, but deferred all details till he should make them the subjects of special remark to the Academy.

Colorado.—Reference was made to the general character of Southwestern Colorado, the interesting topography of the region, especially the vast plateau which rises westward from the base of the Rocky Mountains on to the slopes of the Wahsatch ; the ascent of Marshall's Pass by the Denver and Rio Grande Railroad, the most remarkable feat of railroad engineering performed in the country, and the exceedingly picturesque region about the Pagosa, the greatest hot spring on the continent. Where the San Juan River issues from the mountains a prairie occurs, surrounded by picturesque forest-clad hills, and with a beautiful view of snow-clad mountains in the distance. In the centre of the prairie lies a basin 40 by 60 feet across, boiling like a huge caldron, the ebullition being produced by the violent escape of carbonic acid gas. The banks are lined by the remains of beetles, snakes, etc., destroyed by too trustful reliance upon the hot waters, and by interesting mineral deposits. This is one of the most beautiful places in the country and likely to be a famous resort.

Along the route from Pueblo to Gunnison and Lake City, and thence eastward by Del Norte, there are some places of resort for invalids and pleasure-seekers, which are destined to be very well-known, being far more beautiful and salubrious than the now celebrated localities at Manitou and Colorado Springs. One of these is Wagon Wheel Gap, on the Rio Grande. The river is a rapid, turbulent stream, and the Gap is seven to ten miles long, just wide enough to permit a wagon-road. Then a wide, open space is reached, the basin of an ancient lake, girdled by a wonderfully beautiful amphitheatre of mountains. Here 8500 feet above the sea, the hot springs, charming rides, fine hunting and fishing, an atmosphere as pure and clear as crystal, constitute the attractions of a resort, which far surpasses any other, and which will be reached by the railroad now being pushed through the Gap about January 1, 1882.

From Gunnison, specimens have been recently brought of magnetite and hematite, which probably represent inexhaustible masses, and at Crested Butte, within twenty-five miles of this locality, is found the best coking coal in the West. The region borders on a volcanic area, and the coking coal is from that portion of the basin which has mostly escaped the alteration by volcanic heat. It is firm and not affected by the weather, with a small amount of ash and sulphur.

On Anthracite Creek are found many thousand acres of anthracite of better quality than that of Pennsylvania. Recent analysis made at the School of Mines, New York, shows it to contain less than one per cent. of sulphur, and three per cent. of ash.

The forest vegetation of Colorado is very simple. The pinion or nut pine is very common, also the yellow pine (*P. ponderosa*), Douglas' spruce, Menzies' spruce, etc. In the mountains the general vegetation is picturesque but not so varied as in the lowlands. The following plants are among the most characteristic in the lowlands of Colorado and Utah.

The evening primrose (*Œnothera Cæspitosa*), with its large beautiful white flowers.

The wild tobacco (*Nicotiana attenuata*).

The sun flower (*Helianthus*).

The bee flower (*Cleome integrifolia*), presenting purple acres by the roadside, and the yellow species (*C. lutea*) less common.

The American primrose (*Primula Parryi*).

The pasque flower (*Anemone patens, Var. Nuttalliana*).

The *Eriogonums*, about twenty species, coloring whole mountain sides yellow.

The Oregon grape (*Berberis aquifolium*).

Phacelia circinata, in tufts of purple flowers on rocky slopes.

The lily (*Calochortus Gunnisoni* and *C. Nuttalli*), or "black-eyed Susan" (Indian—" Seego "), very plenty in the moister portion of the sage-plains.

The clematis (*Anemone alpina*), with its purple flowers.

The penstemons, of which 20 or 30 species are peculiar to that county, deep crimson, pink, and purple and blue in color, often very showy, and so abundant that whole acres of ground are colored by them.

The columbine (*Aquilegia canadensis*), and also a much larger species (*A. cerulea*), clothing the mountains of Colorado and Utah, with blue, cream-colored, and white flowers. A large number of dried plants were exhibited from a collection of several hundred species just brought on from Colorado, with collections procured from Prof. Marcus Jones of Salt Lake City, and others.

October 24, 1881.

SECTION OF PHYSICS.

Vice-president, Dr. B. N. MARTIN, in the Chair.

Thirty-one persons present.

Mr. W. LE CONTE STEVENS read a paper, of which the following is an abstract.

WHEATSTONE AND BREWSTER'S THEORY OF BINOCULAR PERSPECTIVE.

For some time after the publication of Sir Charles Wheatstone's essay (1) in 1838, on the Physiology of Vision, this subject was studied with much zeal by Sir David Brewster, whose name is permanently associated with the lenticular stereoscope, an instrument now familiar in every household. Although the theories advanced by these two physicists to account for the illusion of binocular relief have since been shown insufficient, their mode of accounting for the estimate of distance as perceived in the stereoscope has been quite generally accepted. In 1844, Brewster published an essay (2) "On the Knowledge of Distance given by Binocular Vision," in which he elaborated and abundantly illustrated the idea that the apparent distance of an object is determined by the intersection of visual lines. The stereoscope had already been explained as an instrument by which rays of light from two slightly dissimilar pictures were made to enter the eyes, as if coming from a single object into which they are combined in front, and on each point of which the visual lines could be made to meet. Thus, in Fig. 1, if rays from the conjugate foreground points, A_1 and A_2, be

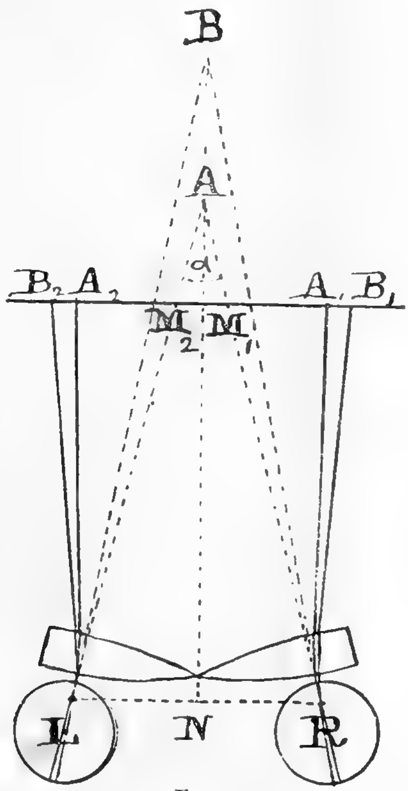


FIG. 1.

(1) Phil. Transactions, 1838, Part II.
Reprinted in Phil. Magazine, s. 4, vol. III., April, 1852.
(2) Edinburgh Transactions, vol. XV., Part III., p. 360.

deviated by the semi-lenses, they appear to have come from A. In like manner, the background appears at B. If i = interocular distance RL, and a = optic angle, then for the distance of A we have

$$D = \frac{1}{2}\, i \cot \frac{1}{2}\, a$$

From this formula it is obvious that D ceases to have any positive finite value when the visual lines cease to converge.

If the semi-lenses be taken away, and A_1 and A_2 be removed to M_1 and M_2 respectively, while the convergence of visual lines remains unchanged, the images still appear at A and B. Wheatstone seems to have been the first to show experimentally that the illusion of apparent solidity can be obtained in this manner from a pair of projections representing the same object from slightly different points of view. If the eyes be properly trained, the visual lines may be directed to points whose distance is greater or less than that of the objects regarded at the same moment, and Brewster described many striking illusions thus obtained without the aid of the stereoscope. The principle applied by him, as described in the paper to which reference has been made, may be briefly given, and his results can be easily tested by any one who is accustomed to analyzing his own visual sensations. Upon a uniform horizontal surface (Fig. 2) let two lines, A C and B C, be drawn, forming a small angle, β, with its vertex toward the observer. Let the eyes,

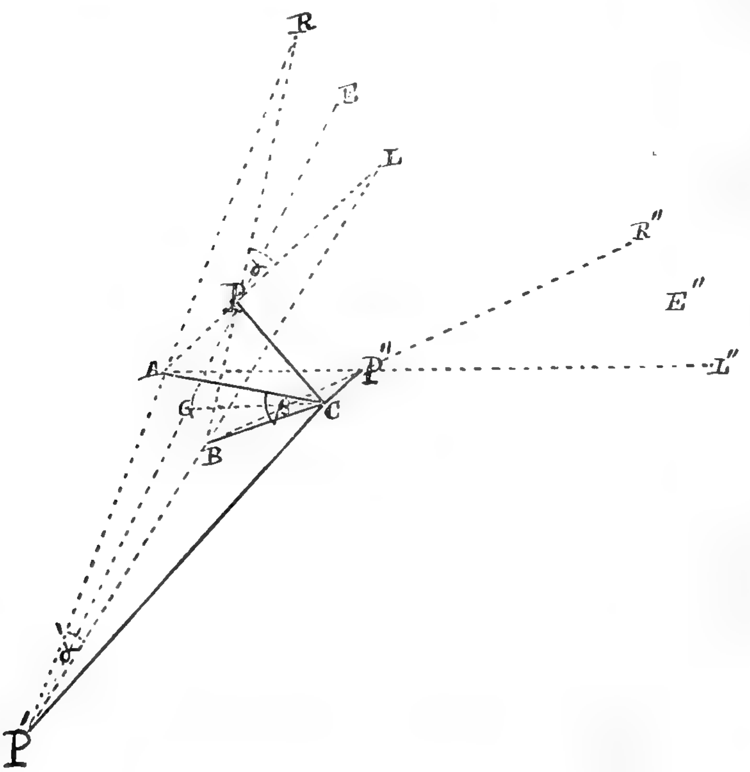


FIG. 2.

R and L, be placed above this. If they be directed to the point C, this appears in its true position. If the right eye be directed to B and the left to A, the axes meet at P; this point Brewster calls the binocular centre; and since the retinal images of B and A correspond, the visual effect is that of the union of these two external points at the binocular centre. Sweeping the glance toward C, the two lines appear united in the air, and P C is the apparent position of the combination, intermediate in direction between two monocular images, which may be disregarded or hidden from view with screens. If the convergence of visual lines be now diminished, the binocular image is lost until the right eye becomes directed to A and the left to B. The two points appear united at P′, and the line P′C now appears in the air on the further side of the surface. If the convergence be increased till P is again the binocular centre, and the face be lowered and withdrawn till the eyes are at R″ and L″, then C P″ becomes the position of the variable external image. And if lowered until R″L″ coincides with the surface, C P″ vanishes at the moment of becoming coincident with the prolongation of G C, the median of the triangle A C B.

Brewster's formula for determining the distance of the binocular centre from G is easily deduced and applied.

Let i = interocular distance, R L.

" a = interval between the corresponding points, A and B.

" b = distance, G E, between card and observer.

" x = distance G P, or G P′, which is positive when measured toward the observer, negative in the direction opposite. Then, observing the usual rule of signs, we have, by Geometry,

$$x = \pm \frac{a\,b}{i \pm a}$$

Applying this formula, Brewster constructed a table of distances for the binocular centre. For negative values it is seen that x becomes infinite when the visual lines become parallel; and, if they be slightly divergent, the binocular centre is far in the rear of the observer. Either of these conditions would make binocular vision impossible if the theory be correct. In testing the experiment with trained eyes, it is found quite possible to secure binocular fusion of the images of A and B when the interval between these points equals or slightly exceeds the interocular distance. It is also found that fusion of the images of the whole line at any given instant is impossible, especially when the angle β is large, or the lines are viewed very obliquely, as from R″ and L″. If the images of A and B fall on corresponding retinal points, the resulting sensation is binocular fusion, whether the visual lines be convergent, parallel or divergent; and the images of any two points nearer or farther apart cannot fall on corresponding retinal points at the same moment with those of A and B, though small differences are easily neglected. Whatever may be the importance therefore of optic convergence, as a factor ordinarily in determining the binocular judgment of distance, it has no such exclusive and measurable value as that attributed in Brewster's experiments; and the apparent distance of objects viewed through the stereoscope is obviously not determined by intersection of visual lines, if conditions are such as to render these parallel or divergent. The visual effects of optic divergence can be more conveniently studied by using stereographs than by the method already described, and a modification of Wheatstone's reflecting stereoscope affords the best means of measuring variations of the optic angle. As the lenticular stereoscope, however, is now almost universally employed, it is important that this instrument, as found in the market, be examined first.

By diminishing the natural convergence of visual lines, the stereoscopic effect of binocular relief can be quite easily obtained, while gazing upon a stereograph, without any instrument, when the interval between corresponding points of the two pictures does not exceed that between the observer's optic centres. This distance does not often differ very much from 64 mm., which may be taken as an average value. In Fig. 3 the distance between the two central dots is 50 mm. If the reader will fix his gaze upon a point ten feet off, just visible below the edge of the page, and then suddenly raise the visual lines to the figure without changing their convergence, he will see three circles instead of two; the central one moreover will appear as the base of a cone whose vertex is pointed toward him, but capped with a small circle. A little attention then will reveal the fact that when the dots are seen distinctly and singly, the small circle is double and slightly indistinct, and *vice versa.*

On stereographs, however, the interval between corresponding points is always greater than 50 mm. As the result of measurement made upon the foreground intervals of 166 cards, European and American, taken at random, the mean value I have found to be 72.9 mm., the maximum being 95 mm. If binocular combination is secured without

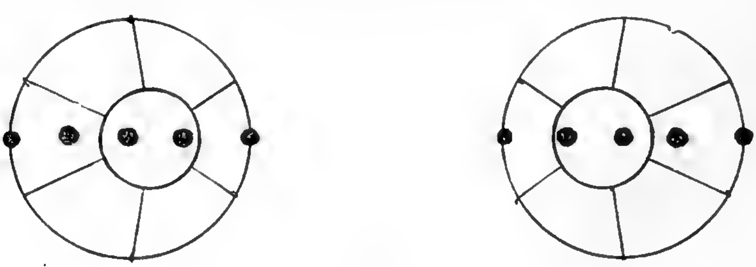


Fig. 3.

the stereoscope, therefore, optic divergence is nearly always necessary. To ascertain the extent to which this is counteracted by the semi-lenses of our best stereoscopes, 30 pairs of these were kindly loaned me by Mr. H. T. Anthony, of New York. With very slight variation, their focal length was found to be 18.3 cm., and their deviating power not sufficient to prevent the necessity of optic divergence, when the pictures are binocularly regarded through them, if the stereographic interval exceed 80 mm. As this limit is not unfrequently exceeded, optic divergence is often practiced unconsciously in using the stereoscope. Every oculist is familiar with the mode of using prisms to test the power of the muscles of the eyeballs, for both convergence and divergence of visual lines, and knows that 4° or 5° of divergence is not uncommon. Helmholtz (3) refers to the use of stereographs for the same purpose.

But familiar as is the production of optic divergence by artificial means, little or nothing seems to have been written in regard to the modification which the possibility of it imposes upon the theory of binocular perspective held by both Wheatstone and Brewster, accepted by most writers on vision since their time, and abundantly reproduced in our text books on Physics.* Of these I have not been able to find one that gives any account of the stereoscope except on the hypothesis that the visual lines are made to converge by the use of this instrument. On the uncertainty attached to the judgment of absolute distance from convergence of visual lines alone, Helmholtz (4) has written more fully than any one else. It is unfortunate that no English translation of his masterly work on Physiological Optics has ever been published. Although he gives no analysis of the visual phenomena produced in binocular fusion by optic divergence, his discussion of the judgment of distance would certainly tend to cast some doubt upon the explanation of vision through the stereoscope, as found in our text-books. And yet Helmholtz himself employs Brewster's theory in his mathematical discussion (5) of stereoscopic projection. This discussion, on the data assumed, is a model of elegance; but it contains no provision for divergence of visual lines. It is strictly applicable to the conditions involved in taking photographs with the binocular camera,

(3) Helmholtz, Optique Physiologique, pp. 616 and 827.

* Nov. 15th. Since the above was put in type, I have received from Prof. C. F. Himes, of Carlisle, Pa., an article written by him in 1862, in which he mentions his successful attainment of binocular vision by optic divergence, and criticises Brewster's theory of distance in relation to the stereoscope. Though his observation was independent, as my own was also, I find that he was preceded by a German, Burckhardt, in 1860 or 1861. I have already referred to Helmholtz in this connection (*Am. Journal of Science*, Nov., 1881, p. 361), and therefore have claimed no priority in discovering the possibility of this unusual, but still voluntary, employment of the eyes. It is the more remarkable that in our text-books the assumption should be so universal, that convergence of visual lines is a necessity in binocular vision for the determination of the apparent point of sight.

(4) Idem, pp. 823, 828.

(5) Opt. Phys., p. 842.

and to the projection of images viewed in the stereoscope when the convergence of visual lines is identical with that of the camera axes, but not otherwise. Instead of human eyes we may assume a pair of camera lenses, an interocular distance apart, and a pair of sensitized plates behind them. Helmholtz's formulas enable us to determine the stereoscopic displacements in the images projected. If proofs from the negatives thus obtained be inverted and placed in front of a pair of eyes in such manner that the visual lines passing through corresponding photograph points shall bear to each other the exact relation that existed between the secondary camera axes that terminated in them, these two points will appear as one, and nearly at the distance of the real point in space to which the camera axes were converged. The effect is much the same as if the eyes, with normal convergence of visual lines, had been substituted for the cameras. But if the proofs be too near together or too far apart, increase of convergence makes the whole picture seem nearer, while divergence makes it farther. The relation between the different parts having been fixed at the time the picture was taken, increased convergence makes the distance from background to foreground seem less, divergence makes it greater. No one can have failed to notice the gross exaggeration of perspective often seen in the stereoscope, when the pictures are so far apart as to make the visual lines parallel or divergent, while the angle between the camera axes, when they were taken, was relatively large. But in no case do these conditions cause variations of such magnitude as Brewster's theory of binocular perspective would demand. This is easily illustrated with Wheatstone's reflecting stereoscope.(6) Suppose the stereograph to represent a concave surface with the opening toward the observer, and that the arms of the instrument are properly adjusted. If they are pushed back, so as to make the visual lines divergent, the cavity apparently recedes and deepens ; if pulled forward, so as to make them strongly convergent, it seems to approach and grow shallow. The apparent diameter of the image enlarges in the first case and diminishes in the second. Wheatstone notices this last variation in the account which he gave of his invention and its applications, in 1852, in the Bakerian lecture before the Royal Society (7) ; but, strange to say, the variation which is produced in apparent distance and depth under the same conditions seems to have escaped his notice, and the possibility of using his instrument to test the peculiarities of binocular vision with divergence of visual lines, seems not to have occurred to him. For the refracting stereoscope, however, like Brewster, he constructs a table of apparent distances corresponding to various optic

(6) For description, see Phil. Mag., s. 4, vol. III., June, 1852, p. 506.

(7) Phil. Mag., s. 4, vol. III., p. 504.

angles, and applicable in using the binocular camera for the purpose of taking slightly dissimilar pictures of the same object. He adds, (8) "when the optic axes are parallel, in strictness there should be no difference between the pictures presented to each eye, and in this case there should be no binocular relief; but I find that an excellent effect is produced, when the axes are nearly parallel, by pictures taken at an inclination of 7° or 8°, and even a difference of 16° or 17° has no decidedly bad effect. There is a peculiarity in such images worthy of remark; although the optic axes are parallel, or nearly so, the image does not appear to be referred to the distance we should, from this circumstance, suppose it to be, but it is perceived to be much nearer." This would not have seemed anomalous to Wheatstone, had he supposed binocular vision possible with divergence of visual lines, and entered into an analysis of the resulting visual phenomena. This analysis will be given in a future paper.

Oct. 31, 1881.

GENERAL SECTION.

The President, Dr. J. S. NEWBERRY, in the Chair.

Twenty persons present.

The following paper was read by Mr. JOHN H. FURMAN:

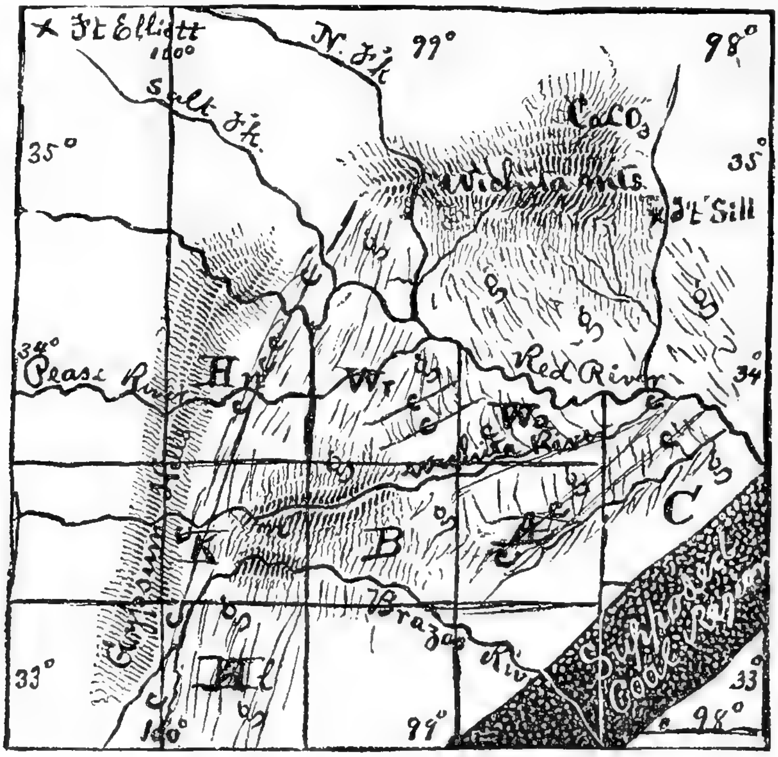
"THE GEOLOGY OF THE COPPER REGION OF NORTHERN TEXAS AND THE INDIAN TERRITORY."

The well-marked cretaceous beds of Parker County, Texas, extend for 30 miles north of west from Weatherford, on the road to Graham. They consist of strata of shelly limestone, sandstone and shaly clay, the latter grayish or reddish in color. An occasional thin seam of soft coal is found; and the water is strongly impregnated with lime. A stratum of sandstone stretches for thirty miles N. W. from Fort Worth. In this rock springs are found containing sodic carbonate, similar to the waters of the artesian wells of Fort Worth, Tarrant County, at a depth of about 270 feet. Towards Graham, the country assumes a semi-mountainous appearance, and, for twenty-five miles or more, sandstone ridges alternate with prairies, the hills being covered with scrub oak. Some of the ridges attain an elevation of two or three hundred feet above the prairies. The strata are horizontal, and large portions of the original surface have been carried away by erosion. The upper stratum is in many places a conglomerate, made up of small pebbles. In this region the seams of coal met with are generally soft, and the only workable

(8) Idem, p. 514.

bed known is one about three feet thick, yielding a fair quality of bituminous coal, which crops out and has been traced for several miles near the Clear Fork of the Brazos river in Young County. This supposed coal region has a general N. E. and S. W. direction.

Approaching Graham the prairies begin to resemble the plains; and the ridges, capped with sandstone, show bases of mottled reddish-colored shales, or clay; salt springs and salt streams are found, indicating the border of the great alkaline region. From Graham to Fort Griffin in Shackleford County, thence north in Throckmorton County, the country rises. Every few miles a steppe is mounted, the face of the escarpments showing horizontal thin limestone strata. The same features continue, and then the country slopes towards the Brazos river.



SCALE—52 MILES TO 1 INCH.

A.	Archer County.	*Wa.*	Wichita County.
B.	Baylor County.	*Wr.*	Wilbarger County.
C.	Clay County.	*c. c. c.*	Copper Bed.
Hl.	Haskell County.	*g. g. g.*	Gravel Drift.
Hn.	Hardeman County.	*n.*	Narrows.

Turning westward through Haskell County, the surface lowers again towards the Brazos, the river coursing south to north, and a plain is crossed, the ground differing from any observed. The soil is mixed and covered with gravel, in many places several feet deep. The pebbles vary in size from half an inch to an inch and a half in diameter, and consist of feldspar, quartz, porphyry, and basalt. On the western side of Haskell County the copper bed is reached not far from the Brazos river; and west of the copper a great belt of gypsum hills, several miles in width, extends northward, parallel with the copper bed, into the Indian Territory. Gypsum occurs there in most of its forms, including selenite which has been locally mistaken for mica.

On reaching a scene of attempted mining operations in search of supposed veins of copper, a very short examination convinced me that no vein would ever be discovered. Denudation has laid the bed bare, sweeping away the larger portion uncovered and leaving only patches; but these were sufficient to give a clear conception of the mode of occurrence. The copper-bearing stratum is an ashy-colored clay shale, more or less tinged with green, the upper portion showing the deep green carbonate of copper, usually two or three inches thick. Overlying this stratum is a cap-rock of gypsiferous sandstone, about three feet thick, with a layer ⅛ to ¼ inch thick, impregnated with carbonate of copper, as though it had soaked it up from below. Underneath the gray or green bed an intensely red clay shale is generally found. Nuggets of copper are scattered over the surface of the red bed, with pieces of cuprified wood and nuggets of iron pyrites. In the wood the original structure in many instances is perfectly preserved, also appearing cuprified in all stages of decay, as though it had become half rotten before the petrifaction was effected. The overlying sandstone frequently contains biscuit-like concretions of gypsum. Juniper trees abound and also cover the gypsum hills, the perfectly preserved cuprified wood, with its knots and bark, showing a fac-simile of that growth. I found in the gray bed fragments of wood partially unaltered, as though it had just commenced to absorb copper; also large pieces of coal, three or four inches or more in diameter, the cracks of the same piece being filled with crystalline carbonate of copper, or with white gypsum, thus appearing veined with copper and gypsum. In parts of the bed remaining the resemblance to piles of ashes and charcoal is strikingly deceptive. In one shaft, sunk to a depth of about thirty feet, the horizontal position of the strata was confirmed, the shaft passing through the cupriferous gray bed, and then through a succession of layers of red shale and soft red sandstone, in which not a trace of copper was found. The gray stratum extends seventy-five feet or more under a point of the gypsum hill. In a tunnel traversing this stratum I noticed occasionally pebbles belonging to the gravel drift. This copper formation has a general north and south course, usually less than fifty yards in width, and was traced for a distance of eight or ten miles to the southern boundary of Haskell County.

At one point the gray bed lies between beds of sandstone; the red bed does not appear, and the underlying sandstone strata are almost white, laminated, and very hard. The bed is more than two miles distant from the gypsum hills; the gravel drift is noticeable and even abundant. Observing the nuggets of copper ore and the drift pebbles lying about in places on the red bed, the idea forced itself upon me that there might be a remote connection between the two. However, the nuggets of ore are evidently concretions, and no pebbles occur in the gray bed. The gypsum range extends several miles across, with a western declivity similar to that on the eastern side. A plain, a little over one hundred feet below, reaches beyond to the foot of the great Llano Estacado. On these hills and on this western plain the gravel drift is wanting.

The copper bed was traced five miles further to the north: also in Knox county, not far from the Wichita river, and forty miles or more north of the southern portion of Haskell county: its occurrence was also reported north of the Wichita river. The copper band here lies between the sandstone and gray bed, with the red beds beneath. Eastward, between the Brazos and Wichita rivers, the gravel drift is abundant, with many stones of greater diameter. At the "Narrows," between the Wichita and Brazos rivers, the width is only sufficient to admit the passage of a single wagon. Continued caving in of the bluffs of the two rivers has widened an immense eroded area, rendering a large surface valueless, and while the channels of the rivers are several miles apart, their junction is only a question of time. In the copper region of the little Wichita river, near the centre of Archer county, the ore occurs under the same general conditions, with a different course, N. E. and S. W., and copper nuggets, coal and cuprified wood are found.

Embedded in the overlying sands'one, in some instances several feet above the gray bed, the sandstone frequently attains a thickness of more than fifteen feet. The cuprified wood is altogether different from that of Haskell county, and resembles the wood of the mesquite tree, which I found scattered about. The gravel drift here is identical in character with that of the region further west, and pebbles occur in the gray copper-bearing bed beneath the sandstone. The extension of the gravel drift of Haskell county, beyond the Brazos river system, its absence west of the gypsum hills, the larger size of the pebbles in Knox county, bordering the Wichita river, and the occurrence of the drift only in the vicinity of the copper-bearing lines mentioned, and in Archer county, suggested to me a possible relationship of some kind between the two, perhaps their origination in the same region. Between the Wichita and Pease Rivers I crossed several copper-bearing beds, having a general northeast and southwest direction. In Wilbarger County the gravel drift is in great quantity, and boulders from three to seven inches in diameter occur. In places, and having a northeast and southwest bearing, heavy deposits or lines of gravel and boulders attract attention, appearing as though a great flow towards the southeast had met obstructions along its course, the great incline of this region being directed towards the southeast. Beyond Pease River the gravel drift lessens, but the large boulders are occasionally seen as far west as the gypsum hills. Not far north from the centre of Hardeman County I again found the Haskell County copper bed, the accompanying sandstones being thin and much mixed with gypsum. The copper bed reaches higher than the surrounding country, except the gypsum hills to the west. From this high locality of the copper, known as Prairie-dog Mounds, the country inclines on one side northward to a creek emptying into Red River, and on the other side southward to the Pease River. South of these mounds, where only here and there patches of the bed are preserved in the midst of a general erosion, I found the largest mass of copper ore thus far discovered, consisting of an aggregation of cuprified wood, resembling the trunk of a tree, more than one foot in diameter.

Beyond Red River, the bed continues to the vicinity of the Salt Fork of Red River, distant but little over 20 miles from the Wichita Mountains of the Indian Territory. The bed probably continues nearly to the western end of these mountains, and here must be found the true centre of elevation and the origin of the gravel drift. The Haskell County copper bed was also traced south to the Wichita River, thus establishing its continuity from the southern portion of Haskell County, through Knox and Hardeman Counties, into the Indian Territory, a length of more than 100 miles. Subsequently, the northern end of the bed was found a short distance from the western end of the Wichita Mountains, on the south side of the range. The copper formations of Archer and Wichita Counties continue through Clay County to the Red River boundary of the Indian Territory. The gravel drift does not extend to the north of the Wichita Mountains, but a limestone district occurs, about 20 miles in width, that reaches probably as far out to the north, from the Wichita Range, the course of the latter being east and west. This limestone area may be called mountainous, is much disturbed and tilted, and is similar in appearance to the metalliferous limestone formation of Mexico. The Wichita Mountains are mainly made up of porphyries, trachytes and basalt, and appear to be two parallel ranges with transverse ranges and small valleys between. About 12 miles west of Fort Sill an extensive body of hornblende slate makes its appearance between the two main ranges. The drift from the mountains extends to the south and southeast. It is found as far west as the Haskell County copper bed, and as far east as the Archer County copper bed is known. The river channels of that section of the country have been formed since this drift period. The development of the Wichita Mountains seems to have marked the close of a period of uplift and simultaneous erosion.

These mountains have the same general appearance as the Rocky Mountains, which pass through the western portion of Texas and the State of Coahuila, Mexico; and it has been a matter of much interest to observe that similar drifts of local origin are frequently met in the latter regions. The Wichita Mountains appear to be identical in origin with the Rocky Mountains, and constitute the most eastern spur of that system. In Northern Mexico short ranges are encountered, striking east and west, and of these the Wichita Mountains appear to be a reproduction. The Wichita Mountains will be found to contain mineral deposits, possibly of some value; veins of copper ores do exist 40 miles west of Fort Sill, near Otter Creek, in the mountains; but I am convinced that the copper bed or stratum of Northern Texas will prove of no commercial importance.

DISCUSSION.

Prof. NEWBERRY remarked that the communication of Mr. Furman was of great interest, since no accurate description had before been given of the geological structure of the region where the copper occurs in Northern Texas and the Indian Territory. He had received specimens from that region long ago and recognized their similarity to the copper ores of New Mexico, where, in the upper portion of the Triassic formation, copper, forming concretions and replacing wood, occurs in many localities, and has been more or less mined for. In one locality near Abiquini very extensive galleries have been cut in the sandstone in search of copper, which there replaces branches and trunks of trees and forms concretions which are irregularly scattered through the rock. Here the work was done by the early Spanish explorers, perhaps 200 years ago, and the remains of the furnaces in which the copper was smelted are still to be seen at the mouth of the mine. Still further west, in Southern Utah, the same formation carries copper and considerable silver, at Silver Reef enough to pay well for mining, but in no locality yet known are the deposits of copper ore sufficiently concentrated and continuous to make mining for that material profitable: so it would doubtless be found in Texas and the Indian Territory. The copper was deposited, with the Triassic rocks, from a shallow sea in which an unusual quantity of copper was held in solution. This impregnated the sediments found at the bottom, replacing wood and forming as nodules about some nuclei. The aggregate quantity of copper in this formation was enormous, but, except where by the erosion of the beds it accumulated at the surface and could be picked up without any expense in mining, it would hardly pay to attempt to obtain it by ordinary mining processes.

The wood replaced by copper, Dr. Newberry said, was undoubtedly all coniferous, and different from any now living. The beds which contained the cuprified wood also contained much that was silicified. Of this he had examined many specimens under the microscope and had found the peculiar dotted cells which are characteristic of the coniferæ, and these grouped in such a way as to prove the trees to have belonged to the Araucarian group of conifers. So far as yet known, the angiosperms, or higher order of plants, did not make their appearance on the earth's surface until after the copper bearing rocks of the southwest had been deposited.

November 7, 1881.

REGULAR BUSINESS MEETING.

The President, Dr. J. S. NEWBERRY, in the Chair.

Twenty-nine persons present.

A paper by Prof. P. T. CLEVE, University of Upsala, Sweden, was read by Prof. D. S. MARTIN, entitled

OUTLINES OF THE GEOLOGY OF THE NORTHEASTERN WEST INDIA ISLANDS.

(Abstract.)

Prof. Cleve's paper contained a resumé of his observations made during 1868–9, in and around the Virgin Islands, and published in the Swedish language in the *Trans. R. Acad. Sci.* of Stockholm, in 1871. He regards the whole group as of Cretaceous and Tertiary age, with the exception of Anegada, which, like the Bahamas, is Post-pliocene.

The strike of the rocks, and the trend of the entire group, are approximately east and west. The rocks are various, largely eruptive and metamorphic. Of these, Prof. Cleve discussed somewhat fully the character and distribution of the following kinds :—1, Dioryte ; 2, Felsyte ; 3, "Blue-beach" (a peculiar volcanic breccia, locally so-called); 4, Diabase.

All these rocks have great thickness, and indicate long-continued volcanic activity. As in modern lavas, they present two types, basic and acidic.

Metamorphic slates are next described ; and then a partly metamorphic limestone, occasionally with recognizable fossils, sufficient to fix the age as certainly Cretaceous.

Santa Cruz Island is then described, and referred to the same series as the Virgin group. All these islands thus indicate, by their east and west strike, and the great up-turning of their rocks, that they were formed by a north and south pressure, forcing the Cretaceous and associated volcanic beds into a great line of anticlinal and synclinal folds. This period seems to have been about that of the white Chalk; but the force continued to act during the succeeding Eocene time, though with diminishing intensity, as is shown by the less inclination of the Eocene beds. The Miocene strata are little disturbed, and the force would therefore seem to have spent itself by that period.

Prof. Cleve then refers briefly to the occurrence of similar metamorphic and volcanic rocks in the interior of the Great Antilles, and regards the entire series as having been formed by the same general movement of Cretaceous folding, the Virgin Islands forming the eastern extension of the line of elevation.

The Eocene strata are then taken up and discussed, as they occur in the islands of St. Martin and St. Bartholomew, just east of the Virgin group. Professor Cleve regards these islands as wholly of Eocene age, claiming that the eruptive rocks, of which they mainly consist, are *interstratified* with the limestones, which contain fossils of the age of the Calcaire Grossier, of the Eocene of Paris. He then traces the occurrence of Eocene strata in Antigua, Guadaloupe, parts of Trinidad, and largely in Jamaica; and re-affirms his conclusion that the movement which raised the Great Antilles and the Virgin islands continued during the early Tertiary, though with lessening force.

The Miocene formation is then considered. It forms the small island of Anguilla, and occurs on several of the islands, south to Trinidad; but has immense development in the Great Antilles. It is chiefly a limestone series, is generally little disturbed from a horizontal position, and at times may be seen resting unconformably on the Eocene. By this time, evidently, the disturbing movements had ceased to make themselves felt.

The later Tertiary rocks, Pliocene and Post-pliocene, have not been very clearly marked off from each other or from the Miocene. But to the Post-pliocene period are referred the Bahamas, Anegada, and the remarkable series of volcanic outbreaks that characterize the islands of Saba, St. Eustatius, St. Kitts, Nevis, Monserrat, Guadaloupe, &c. On St. Kitts, Prof. Cleve describes a limestone with over forty species of fossil shells, all but one of which are identified with living species of the Caribbean sea. The same is true of Anegada.

The elevation of the Miocene strata of the Great Antilles took place apparently by a "continental" up-lift, whereby large areas of marine deposit were raised without folding or disturbance. Professor Cleve suggests that this movement may have been accompanied by a sinking of part of the sea-bottom in the Caribbean region to the south-east, and that, on the limit between the areas of rise and of depression, fissures and faults may have occurred, through which these volcanic outbreaks of the Leeward islands found exit, in the Post-pliocene time.

DISCUSSION.

Mr. A. A. JULIEN confirmed the accuracy of these petrographical distinctions of the rocks of the Lesser Antilles, from the results of observation during a residence of four years on Sombrero and vicinity. The island of St. Eustatius consists mainly of volcanic ashes in a thick tabular and horizontal stratum with vertical faces along its coast. This is flanked on the south end by a volcanic cone with extinct crater, of which the bottom is occupied by a plantain plantation, but the sides are bare, and consist of a dark basaltic rock; and on the north end by two lower cones, not visited but probably volcanic. On the island of Saba the rock is light colored, rich in crystals of sanidine, and apparently a trachyte, constituting a remarkably sharp volcanic cone, with its sides deeply furrowed from top to bottom by eroded ravines; certain depressions upon the summit, resembling craters, present in some localities sulphur deposits which have been found of commercial importance.

However, the conclusion of Prof. Cleve, as to the recent age and eruptive character of most of the crystalline rocks of this region, appeared surprising in view of their metamorphic associates, and of their similarity to those of the Archæan areas identified by Hartt in Brazil. It was a question whether a nucleus of Archæan, or, at latest, metamorphic pre-Silurian rocks, in general highly tilted, does not form the axis of such islands as St. Martin, St. Barts, etc.

Prof. D. S. MARTIN questioned whether a corresponding movement of disturbance should not be also found in the Cretaceous strata of a region no farther removed than that of the vicinity of our own Gulf coast.

Dr. J. S. NEWBERRY remarked that the importance of the subject of the age and origin of these crystalline rocks still demanded their re-examination and a review of Prof. Cleve's conclusions by some worker of experience in this peculiar field. One of the most interesting topographical features on this continent consisted in the line or axis of elevation marked by the Windward Islands, separating the deep basin of the Gulf of Mexico on the one side from the abyss of the Atlantic Ocean on the other. It presents a prolongation and connection of the mountain chains which run along the eastern border of the North and

South American continents, in a course imperfectly parallel to that on the western border of these continents, with the gulf lying enclosed between these two great ranges. This axis has been the scene of violent volcanic action and has been supposed to mark the place of that mythical area of sunken land, styled Atlantis by the ancients. A tradition long current, recorded by Herodotus and others, points to a densely populated land west of Europe, covered with cities, and threatening the civilization of the Eastern hemisphere, which was punished by the gods by being sunk beneath the sea. According to the recent observations of an English geologist, Mr. Thomas Belt, this legend may have had some foundation in the former existence of a continent, now submerged beneath the Caribbean sea, through which the peaks represented by the Lesser Antilles constituted a mountain chain. Local disturbances have certainly affected this area, but we fail to find any evidence of corresponding disturbance in the Cretaceous strata of our southern States, except perhaps in continental elevations and depressions. Messrs. Guppy, Gabb, and others have studied the rocks of the region, but, up to this time, no one trained to the examination of the difficult phenomena and problems under discussion.

November 14, 1881.

SECTION OF GEOLOGY.

The President, Dr. J. S. NEWBERRY, in the Chair.

Twenty-four persons present.

A paper was read by Dr. ALEXIS A. JULIEN on

THE EXCAVATION OF THE BED OF THE KAATERSKILL, N. Y.

(Abstract.)

This paper was supplementary to one read before the Academy two years ago, concerning the phenomena of erosion, glaciation, etc., in the Catskill Mountains, in the vicinity of the Kaaterskill Clove.

Flexure of Strata.—Prof. James Hall has indicated the existence of four lines of flexure, running from N.E. to S.W., the synclinals occupying the summits of ranges, and Prof. Arnold Guyot locates one of these at Slide Mt. The dips at the entrance of the Clove vary from 8° to 10° to the W.N.W., becoming only 3° four miles to the westward, *i. e.*, more nearly horizontal towards a shallow synclinal fold supposed to occupy Hunter Mt.

One of the most interesting discoveries of Guyot was the linear series of three maxima of altitudes above 4000 feet, Slide Mt., Hunter Mt., and Black Dome. The gentle flexure of the whole stratum required to produce this line of maxima may be shown as follows, in the range running S.E. and N.W. through Hunter Mt., 35 miles long. Toward the S.E., the descent from the crest of Hunter Mt. (Alt., 4038 feet), to Overlook Mt. (3150 feet), is 888 feet, in 9½ miles, equivalent to 1 in 56, or about 1°; toward the N.W., from Hunter Mt. to Utsyanthe Mt. (3203 feet), the descent is 835 feet in 25 miles, equivalent to 1 in 158, or less than ½°.

Another similar series of maxima, however, occurs further to the westward, consisting of Graham Mt. (3886 feet), Bear-pen Mt. (3545 feet), and Ashland Pinnacle (3420 feet), distant respectively 9, 12, and 15 miles westward of the former series. This southward convergence of the axes of these two folds may probably account for the increased protuberance and greater elevations in the Southern Catskills.

Newly determined altitudes.—Many new determinations have been made of points in the vicinity of the Clove, by means of an excellent aneroid, with constant reference to the numerous stations in the vicinity whose altitudes have been accurately obtained by Guyot. A few are here subjoined:

	Feet.
Hotel Kaaterskill, on South Mt.	2466
Parker Hill, summit	2565
Parker Mt., "high ledge."	2874
Clifton House	2101
Newman's ledge, on North Mt.	2486
Gap between E. and W. peaks, North Mt	3116
Toll-gate on Mt. House road	760

Glaciation of summits.—All the crests near the Clove have been now examined. On none above an altitude of 2900 feet have glacial striæ been found, in part because they consist of thinly laminated flags deeply disintegrated by frosts. The highest striæ discovered were found on Parker Mt., "High ledge" (2874 feet), running S. 18° W. (magnetic), and under the roots of a large tree on the SE. slope of Round Top, at an elevation of 2871 feet, running S. 35° E. However, in all cases, a marked difference exists in the slope of different sides of a peak, the E. and S.E. sides presenting a precipitous face, and the other sides more or less of a gentle slope, made up of low terraces.

The highest striæ yet found in the Catskills occur on Overlook Mt., at an elevation of about 3100 feet, implying a depth of ice in the Hudson Valley Glacier of about or at least 3200 feet. Within the Kaaterskill basin, several miles distant from the Hudson valley, the overflowing ice stream became shallower, having an altitude of about 3000 feet. It thus appears that the surface of the glacier inclined westward over these mountains, with a slope of 200 feet in 3 miles, 1 in 84, say about ½°.

The conclusions of the former paper have been confirmed by recent observation, viz., that two glacier streams have swept over these mountains, the Continental Glacier from the N. W., submerging and carving out the highest peaks, and the Hudson Valley Glacier from the N., later, more shallow, bearing along vast quantities of materials derived from the crystalline and lower Silurian rocks of the Adirondacks and of the Helderberg Mts., and strewing the whole region with their boulders; and that no local glaciers have existed in the Catskills after the retreat of the Hudson Valley Glacier.

Tilting of the Catskill plateau.—In the previous paper an explanation had been given of certain facts which seemed to indicate that the whole formation had been gently inclined to the East and then to the Southeast, before assuming its present W. N. W. inclination, at a period far anterior to the Glacial epoch. A profile section of the ancient Kaaterskill valley was exhibited, reaching from Haines' Falls nearly to the junction of the N. and S. branches of Schoharie creek, proving the gentleness of the slope, the absence of rock, and the existence of a deep and narrow buried cañon, now filled up with moraine material and a capping of peat.

A comparison of the altitudes of Prattsville (1164 ft.), a point on the Western axis, 12 miles distant from the Kaaterskill Clove, and of the lip of the stratum above Haines' Falls (1857 ft.), at the head of the Clove, shows that a depression of the latter point below a line connecting these two points, even to the extent of a single degree, would cause a descent of nearly 700 feet from Prattsville to Haines' Falls, *i. e.*, toward the East. The excavation of the deep Kaaterskill and Plaaterkill Cloves could hardly have been effected by the small streams now occupying their beds. It is more probable that the Schoharie creek formerly flowed, at a higher level, to the eastward into the Kaaterskill Clove, and afterwards toward the south-east into the Plaaterkill Clove, before the latest tilting of the plateau to the W. N. W. caused a reversal of the flow of the stream, in the very opposite direction, through the greater part of the same valley. An objection to this theory presented itself in the obstacle which has created a turn to the S. W. in the North branch of Schoharie creek, near its junction with the South branch. But on recent examination this was found to consist not of rock but of a huge mass of coarse moraine material, deposited during the Glacial period on the southern slope of the Schoharie valley.

Sculpture of the plateau.—In a terrane consisting of strata which dip at varying and perhaps very high angles, the carving out of ranges and production of ravines and gaps may generally be assigned to the occurrence of flexures, of dykes or faults, or of beds whose material is unusually soft, fragile, or rich in minerals of easy decomposition. But the problem of topographical sculpture is less easily solved in a stratum like that of the Catskills, consisting of a regular succession of layers which are horizontally homogeneous and from which the phenomena of disruption are absent. The original disintegration and erosion of the mass which resulted in the production of the ranges was perhaps mainly influenced by the direction of the jointage. With this the trend of the ranges in the vicinity of the Kaaterskill Clove appears to coincide. The ravines, cloves, and deepest notches and valleys may be attributed to the streams of the present hydrographical basins, or to those connected with the ancient eastward and south-eastward inclination of the stratum already considered. But recent observations on the juxtaposition and coincidence of the highest gaps in successive parallel ranges may possibly indicate the remnants—in cross-section—of the beds of ancient streams at that level (about 3000 feet); this conclusion, if confirmed, would signify an inclination of the plateau to the N.N.E. (or to the S.S.W.?) at a still earlier period, that immediately succeeding its elevation.

Kames.—In the upper basin of the Kaaterskill, several isolated hills of gravel, etc., occur at an altitude of 1924 feet, especially on the bank of the stream near the head of the Clove, which are probably kames; their materials, though largely angular, show traces of imperfect stratification. Near "Blythewood," on the North branch of the Schoharie creek, a curious conical and steep isolated kame rises 102 feet above the stream, made up of rounded pebbles of the Catskill grit, rarely a foot in length, overlying a layer of coarse moraine. Its elevation above the sea (1944 feet) exceeds that of any other kame yet observed, those of the Fintry Hills in England reaching 1280 feet, and those of the Androscoggin Lakes, in Maine, 1600 feet. A very interesting series of from eight to twelve very low kames—like parallel ridges, often curving, made up of large rounded boulders—was also found to follow the course of the Kaaterskill near Palenville, in the Hudson Valley, at the mouth of the Clove, at an elevation of about 700 feet; these probably mark the course of the sub-glacial stream which issued from the mouth of the Clove. The paper concluded with observations on a deposit of laminated sand underlying the ground moraine: on the feeble erosion of the slopes of the Clove during the period which has elapsed since the close of the Glacial epoch; and on a new section of the strata of South Mountain obtained from a recent road cutting.

Discussion.

Prof. E. C. H. Day observed that one portion of Dr. Julien's remarks reminded him of an idea which had struck him many years ago, with regard to the surface geology of a valley on the south coast of England, near Charmouth, in Dorsetshire.

The stream in the valley referred to finds its way to the sea through a narrow pass, which, as attested by the rapid wearing of the coast line and its present configuration, could only have been of (geologically speaking) very recent origin. How the valley could have been drained prior to the existence of this outlet was a question which might be met by various hypotheses; and one of these was that there might have been a slight unequal local change of level, sufficient to have had the effect of tilting the surface of the valley, so that its waters were shed then in a direction opposite to that which they now take. This was nothing more than the veriest hypothesis, made many years ago, without any subsequent attempt at verification. It may suggest, however, the possibility of such slight local changes occurring, in addition to the greater movements already distinctly recognized, and the desirability of careful investigation to discover whether such may not be traced in the altered direction of streams and in the existence of ancient and unused water courses—even in our own neighborhoods. It may be added that such local tiltings of parts of the earth's crust would necessarily influence the course of subterranean as well as of subaerial waters, thus altering the distribution and force of springs at the surface.

Dr. J. S. NEWBERRY stated that the Catskills presented a more complex bit of topography and geology, and one that had been more discussed than perhaps any other of similar area in the country. It was once supposed that these mountains were composed of a single geological formation, which, from this fact, was called the Catskill group; and it was supposed to be a detached table land, deeply carved by erosion. The late Col. Jewett, of Albany, found strata containing Chemung fossils in the Catskills, and from this inferred that the mountains were composed of Chemung strata. Prof. Hall and Prof. Guyot, with their assistants, then made a careful study, running through several years, of the topography and geology of all the surrounding region. Their labors established the fact that the Catskills are not an isolated mountain group, but belong to the Alleghany system and are formed by a series of folds or arches composed of the Chemung and Catskill rocks. Of these folds, the convex arches, as is usually the case, were cracked and broken and, therefore, yielded readily to erosion, while the concave arches, protected and solid, yielded less readily and, in time, by the wearing away of their surroundings, were left in relief, forming ridges with a synclinal structure. Hence it will be seen that the topography of the Catskill region is chiefly the result of erosion.

So far as regards the changes of level from subterranean causes, referred to by Mr. Julien, it would certainly be strange if the foundations of the Catskills were proved to be stable. The old name, "*terra firma*," once applied to the crust of the earth, is a complete misnomer.

and it is really a type of instability. Probably throughout the globe local subsidence and elevation are constantly in progress. In the interior of continents we have no evidence or measure of these, but along coasts the water line tells us that changes are constantly and everywhere taking place, in the relative level of land and sea. About New York the coast is sinking, though very slowly, while further north, in places, it is rising, and Greenland is sinking again. Back from the coast there is no such nilometer, and yet we have no reason to suppose that the earth is more fixed. Some indication is given by the reports of those who dwell in mountainous regions, of changes of level, which have shut from their view that which was before visible, or revealed what was before concealed; but these observations have not been made with accuracy and cannot be depended upon.

In a recent paper before the Academy he had shown the vast changes which had occurred along the coast in this vicinity, viz., that the land once stood 600 feet higher than at present: that the Hudson river had then flowed by the city through a channel from 300 to 500 feet deep, now in large part silted up: that the Palisades then stood from 700 to 800 feet above the river: that the Housatonic then flowed through the East river into New York Bay: that a sub-tropical climate then prevailed throughout this region, with a varied and rich fauna and flora, extending up even to the Arctic Sea: that then a depression of the temperature and great change in the climate ensued, with a corresponding alteration of the fauna and flora; but that these changes were very slow and progressive—the snows, which at first rested temporarily upon the Catskill Mountain summits, became at last permanent, and resulted in local glaciers. These glaciers produced extensive erosion, cutting deeply the channels along which they moved. A partial obliteration of their work then ensued through two agencies. First, a continental glacier advanced southward, overtopping all the mountains, grinding down the asperities of the surface, filling old valleys, and banking up a great mass of debris along its margin—a part of which is now Long Island. Afterward, the climate becoming milder, local glaciers were again formed similar to those which preceded the great Glacier, and partially obliterated or modified the results of the ancient erosion. It is a complex problem now to distinguish between the phenomena which have been respectively produced by all these glaciers in varied succession, by the erosion of streams, by flexures of the earth's crust, etc.

The excavating power of glaciers had been denied by some persons; but ice, hundreds of feet and sometimes miles in thickness—as it was in the old glaciers—moving with irresistible force, and having sand, gravel and boulders beneath it, or frozen into it, was the most potent agent of erosion known. The eroding power of the ancient glaciers, which once reached southward to Trenton and Cincinnati, was attested not only by the planed down rocks, but by the immense sheet of transported debris left by the glacier in its retreat.

The glaciated, planed, and polished rocks in the Western States are generally covered by a thick layer of clay, abounding in glaciated boulders. There are also other water-worn materials which have been transported, perhaps thousands of miles, representing the gravel bars sand beds, etc., produced by sub-glacial rivers. Although the materials are entirely of glacial origin, all the stones are here usually rounded. We find in these deposits, called kames or eskers, the evidences of the action of running water produced by the melting of ice, their accumulation in heaps, ridges, etc., having been effected by local causes, waterfalls, streams upon or under the ice, etc.

The finer material produced by the same grinding action has been deposited along our coast in the vast masses of the Champlain clays. It is well known that the drainage of all glaciers results in milky streams; *e. g.*, those which descend from the Alps impart an opalescence to the Lake of Geneva, and the streams from the Cascade Mountains are clouded with silt derived from the small glaciers at their heads. So, during the Glacial period all the fine material was sometimes washed out of the glacial drift, leaving banks and ridges, kames, hogsbacks, etc., of gravel and boulders, and carried by streams to the coast and there deposited along shore in the Champlain clays. The fine flour and bran ground by the glaciers have been sometimes referred to different epochs, but they are produced simultaneously. The Glacial or Champlain clays are of great economical importance to the city, as they are the brick clays of Croton Point, Haverstraw Bay, and other points along the Hudson. Their thickness reaches 100 feet along the lower portion of the Hudson river, 400 feet on Lake Champlain, 500 feet at Montreal, 800 feet at Labrador, 1000 feet at Davis' Strait, and 1800 feet at Polaris Bay. This indicates that the continent was depressed to this extent at each of these points, that the waters of the ocean extended through these valleys, and that here was dead water into which the glacier drainage flowed and was deposited.

In the vicinity of New York City it is evident that the glaciers everywhere over-rode and disregarded the underlying topography. All the surface of the island is strewn with materials derived from the N. N. W., and the rock has been planished and striated with grooves running in that direction. The hills back of Yonkers are covered by trap boulders, which have been conveyed across the river from the Palisade range on its western side; and it is plain that the glacier completely disregarded the depression of the Hudson valley, filled it up to a greater or less extent with *debris*, and so rode smoothly over it. Afterwards this and the other valleys were more or less cleared out by the present streams, but a portion of their contents is generally left in their beds, the tunnel between this city and Hoboken being now driven in fact through a part of this clay deposit. On the east side of the city a narrow cañon, 300 to 400 feet deep, has been proved to underlie the East River; and it would have been a wiser and cheaper plan to construct a tunnel through the clay bottom, for communication with Brooklyn, in place of the present costly and to some extent insecure bridge.

Dr. Newberry finally expressed his interest in the careful study of the erosion and sculpture of the Catskills and desire for its continuance.

November 21, 1881.

SECTION OF BIOLOGY.

The President, DR. J. S. NEWBERRY, in the Chair.

Thirty-one persons present.

The following paper was read by Prof. LOUIS ELSBERG, M. D.:

ON THE CELL-DOCTRINE AND THE BIOPLASSON-DOCTRINE.

Mr. President and Fellows of the Academy, Ladies and Gentlemen:—Last May, at the meeting of the American Laryngological Association, I rendered account of some histological investigations of the cartilages of the larynx, a report of which is published in the October number of the *Archives of Laryngology*. As the structure of hyaline cartilage has an important bearing on my subject of this evening, I crave your attention for a few minutes for a brief review of those investigations.

You know the larynx or voice-box consists of a framework of cartilage or gristle. This cartilage is called hyaline or glasslike, because it is opalescent and looks like milk-glass. Having frequently been examined under the microscope, it has always been looked upon as one of the simplest tissues, namely, as being composed of a hard matrix or basis-substance, in which are imbedded a number of small softer bodies. These softer bodies, the cartilage corpuscles, have since the establishment of the cell-doctrine been called cartilage cells. As these cells were known to be alive, the question which scientific men have had to try to answer was: how can they obtain nutrition, being isolated and enclosed in the firm, unyielding cartilage basis-substance?

Without going too much into details, I may say that it was assumed that nourishing liquid reaches the corpuscle either by imbibition and diffusion or else through canals or fissures in the homogeneous basis-substance. The idea of the existence of "juice-channels" originates with Von Recklinghausen, although others before him had spoken

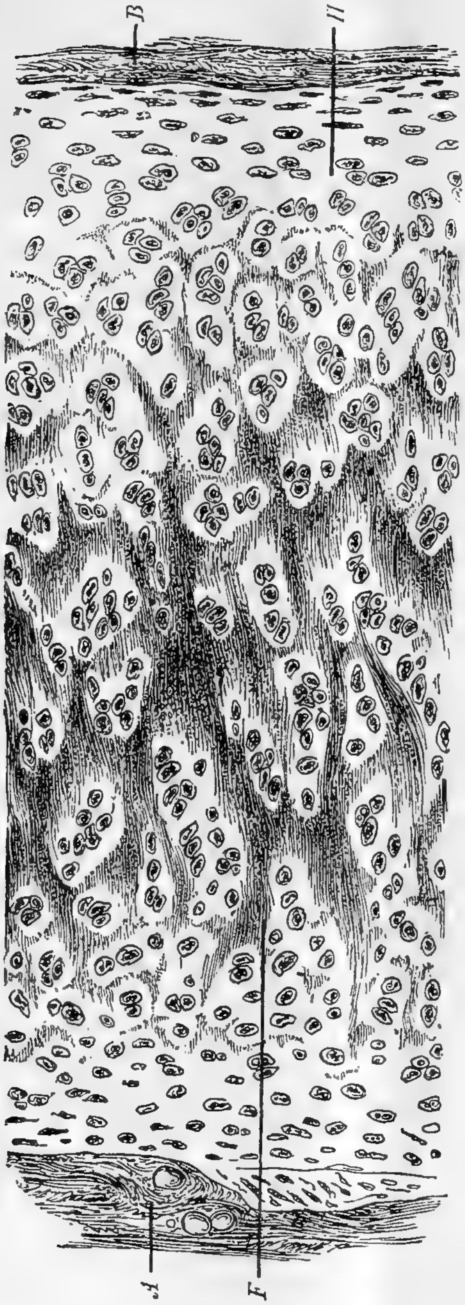


FIGURE 1.—Plate of the Thyroid Cartilage of Adult. Longitudinal Section x 100.

A. Perichondrium towards the mucus membrane. | F. Fibrous portion of cartilage in the centre.
B. Perichondrium toward the skin. | H. Hyaline portion, on either side, near the perichondrium.

FIG. 1 exhibits the appearance of a longitudinal section of the plate of the thyroid cartilage, with an amplification of 100 diam.

of "pores" through which nutrient juices might pass. Budge and others believe in the presence of regular canals for this purpose, while Tillmanns and many with him believe that hyaline basis-substance consists of fine fibrils so closely held together by a cement-substance that the mass appears to be homogeneous. It is supposed by some that this inter-fibrillar cement-substance is a viscous soft material which permits the imbibition of nutrient liquid; by some that there are clefts or fissures; and by others that there are regular channels tunnelled in this cement-substance. On the other hand, Heitzmann, Spina, Flesch and others have found that there are cilia-like offshoots or prolongations of the substance of the corpuscle penetrating into the basis-substance. Such prolongations might carry on nutrition. I have had the opportunity, six or seven years ago, to repeat Heitzmann's observations under his own eyes and with his assistance; but the results as to their correctness, at which I arrived, were to the best of my belief uninfluenced by him.

My own recent investigations have not only confirmed the existence of such offshoots and shown that they form an inter-connected reticulum or network throughout the basis-substance, but I have discovered in several specimens small lumps in this network which, by all the tests applied to them, were proved to be lumps of living matter in various stages of existence! These investigations are illustrated by the accompanying drawings.

Doubt as to the interpretation is impossible: instead of being a mass of basis-substance in which a number of cartilage corpuscles are imbedded, hyaline cartilage is a filigree of living matter, in the meshes of which a number of blocks of basis-substance are imbedded.

Now, for our subject proper.

The founder of the cell-doctrine, Schwann, has recorded in the introduction to his great work, published in 1839, that the doctrine was based to a large extent upon investigation of the constitution of carti-

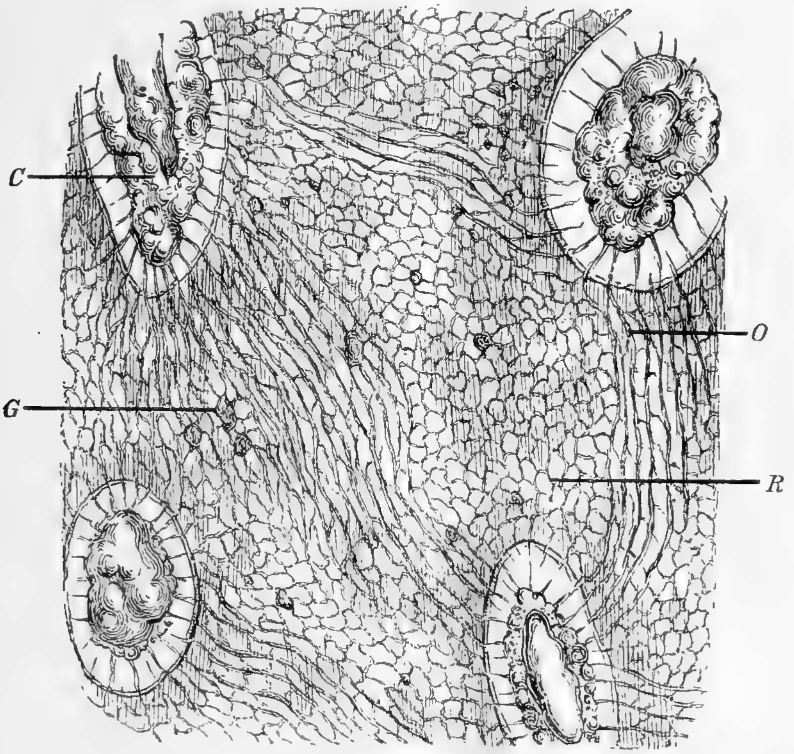


FIGURE 2.—Thyroid Cartilage of Adult, kept in strong Alcohol. Horizontal Section x 1200.

C. Shrivelled cartilage corpuscle. | R. Reticulum in basis-substance.
O. Longitudinal off-shoots. | G. Granules of living matter.

FIG. 2 shows offshoots from the cartilage corpuscles and the network in the basis-substance, with more or less large granules interwoven, as it were, in the network.

lage. After Johannes Müller had described cartilage-corpuscles that were hollow, and Gurlt had spoken of some as vesicles,—when Schwann had succeeded, as he thought, "in actually observing the proper wall of the cartilage corpuscles, first in the branchial cartilages of the frog's larvæ and subsequently also in the fish," he was led by these and other researches to conjecture "that the cellular formation might be a widely extended, perhaps a universal, principle for the formation of organic substances." And just as the study of cartilages has led to the cell-doctrine, which at the time of its establishment was a great advance in biological science; so the further study of cartilage has supplied the basis for a generalization, which is a further development, and must take the place of the cell-doctrine. This is Heitzmann's doctrine of living matter, or, as I have named it, the *bioplasson-doctrine.*

When the term "cell" was introduced in 1838 and 1839, by Schleiden and Schwann, it was believed that, on ultimate morphological analysis, every plant and every animal would be found to consist of a number of minute vesicles or sacs, enclosing liquid contents in which is suspended a more solid body, the nucleus. For fully twenty years this idea has been known to be erroneous. In fact, Goodsir, nearly *forty* years ago—only a few years, that is, after Schwann had established the cell-doctrine and attributed the vital power to the cell-membrane, I say, nearly forty years ago Goodsir had experimentally determined that the seat of the vital process of secretion is not in the vesicle as such, but in the so-called cell contents; Naegeli, in 1845, and Alexander Braun, in 1851, had also shown the cell-wall to be comparatively unimportant; and in

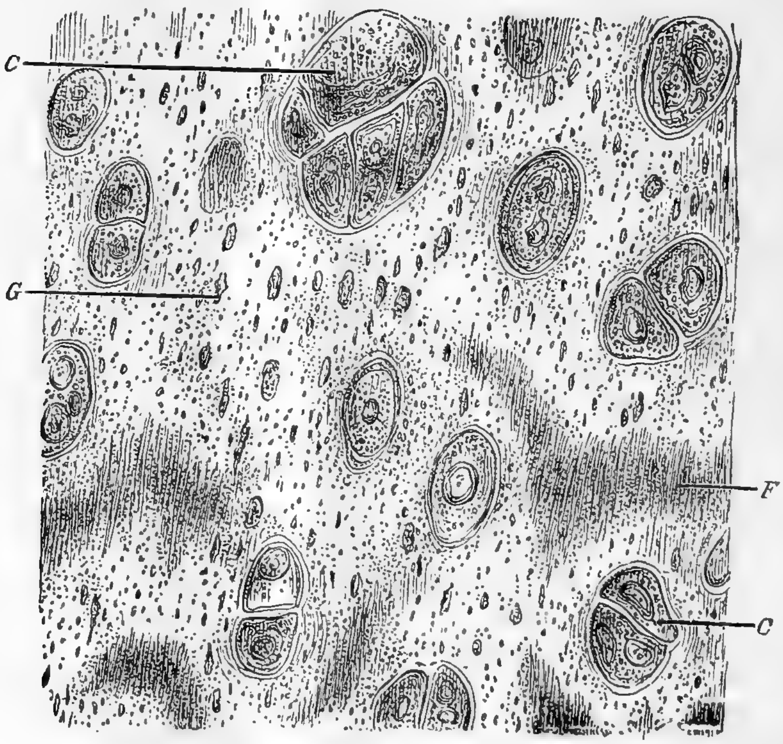


FIGURE 3.—Thyroid Cartilage of Adult. Horizontal Section x 600.

C. Cartilage corpuscle. F. Fibrous portion of cartilage. G. Granules of living matter.

FIG. 3 shows granules of various sizes in the basis-substance, with lower power of the microscope, which granules are seen with higher powers to be connected with the network of living matter, as shown by FIG. 4.

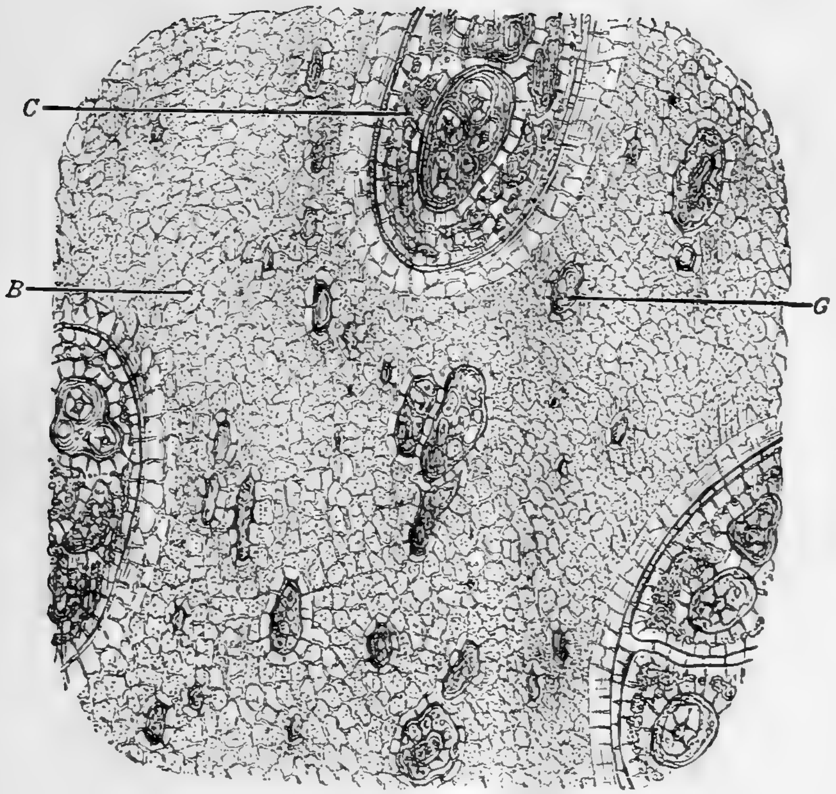


FIGURE 4.—Thyroid Cartilage of Adult. Horizontal Section x 1200.
C. Cartilage corpuscle. B. Hyaline basis-substance. G. Granules of living matter.

1857 Leydig had declared the "cell" to consist only of a soft substance enclosing a nucleus. Certainly, twenty years ago it was proved beyond dispute by Max Schultze, Beale, Hæckel, and others, that what was called a "cell" was not a vesicle, but essentially a jelly-like lump of living matter characterized by the presence of a nucleus; soon after, Robin, Brücke, Kühne, Stricker, and others, conclusively showed that not even a nucleus is an essential constituent of an elementary organism; and biologists were compelled to transfer the power of manifesting vital properties to "living matter," instead of restricting this power to any definite form-element. As long ago as in 1861, Brücke proposed to discontinue the use of the word "cell" as being a misnomer and misleading, and offered as a substitute the expression "elementary organism." Beale proposed, instead, the term "bioplast" to designate any definite mass of living matter, and Hæckel the term "plastid." From the latter I devised the word "plastidule," as synonymous with ultimate molecule of the substance of living matter. Elementary living matter is called with Dujardin "sarcode," or with Von Mohl "protoplasm," or with Beale "bioplasm," or, still better (because it is a designation etymologically more nearly meaning living, forming matter), "bioplasson." Of these four synonymous terms, "protoplasm" is the one best known; but has been used in other senses, as well as to designate merely elementary living matter. I therefore think that "bioplasson" is to be preferred. Of course, *dead* bioplasson is a contradiction in terms: bioplasson deprived of vitality is no longer bioplasson at all, but merely the chemical remains of what *once was* bioplasson. If this be remembered, there will be no confusion, even if the word be used in describing tissues, etc., after death. According to Drysdale, Dr. John Fletcher of Edinburgh was the first, who clearly arrived at the conclusion that "it is only in virtue of a specially living matter, universally diffused and intimately interwoven with its texture, that any tissue or part possesses vitality."

As Fletcher's work was published in 1835, several years before even the establishment of the cell-doctrine, we cannot but agree so far with Drysdale as to say that Fletcher has framed a "hypothesis of the anatomical nature of the living matter which anticipates in a remarkable manner" its discovery! In 1850, Cohn[1] recognized the protoplasm "as the contractile element, and as what gives to the zoöspore the faculty of altering its figure, without any corresponding change in volume." He concludes that protoplasm "must be regarded as the prime seat of almost all vital activity, but especially of all the motile phenomena in the interior of the cell." In 1853, Huxley[2] said, "vitality, (the faculty, that is, of exhibiting definite cycles of change in form and composition), is a property inherent in certain kinds of matter." In 1856, Lord Osborne discovered carmine staining, and distinguished, by means of coloring it, the living formative matter from the formed material, a means which has borne important fruits in the discovery of Cohnheim's staining of living matter by gold chloride, and in that of Recklinghausen's staining all except living matter by silver nitrate.

In 1858, and in a number of later articles,[3] Max Schultze, by showing that, as had been hypothetically supposed by Unger, the movements of the pseudopodia and the granules are really produced by active contractile movements of the protoplasm, as well as by other observations, contributed much to the establishment of the theory of living matter. Hæckel has also for many years, and in various publications,[4] labored to

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[1] "Nachträge zur Naturgeschichte des Protococcus pluvialis." *Nova acta Acad. Leop.-Carol.*, vol. xxii, part i, p. 605.

[2] "Review of the Cell-theory." *British and Foreign Medico-chirurg. Review*, Oct., 1853.

[3] "Ueber innere Bewegungs-Erscheinungen bei Diatomeen," *Müller's Archiv*, 1858, p. 330; "Ueber Cornuspira," *Archiv f. Naturgesch.*, 1860, p. 287; "Ueber Muskelkörperchen und das was man eine Zelle zu nennen habe," *Reichert und Du Bois-Reymond's Archiv.*, 1861, p. 1; Das Protoplasma der Rhizopoden und der Pflanzenzellen, Leipzig, 1863.

[4] Monographie der Radiolarien, 1862, pp. 89, 116; "Ueber den Sarcodekörper der Rhizopoden," *Zeitsch. f. Wissensch. Zoölogie*, 1865, p. 342; Generelle Morphologie, vol. i, pp. 269, 289.

maintain and extend the same theory, of which he thus expresses himself,[1] "the protoplasm or sarcode theory, that is, the theory that this albuminous material is the original active substratum of all vital phenomena may, perhaps, be considered one of the greatest achievements of modern biology, and one of the richest in results." And, says Drysdale[2], "if the grand theory of the one true living matter was, as we have seen, hypothetically advanced by Fletcher, yet the merit of the discovery of the actual anatomical representation of it belongs to *Beale*, in accordance with the usual and right award of the title of discoverer to him alone who demonstrates truths by proof and fact. * * * The cardinal point in the theory of Dr. Beale is not the destruction of the completeness of the cell of Schwann as the elementary unit, for that was already accomplished by others, * * * but that, from the earliest visible speck of germ, up to the last moment of life, in every living thing, plant, animal, and protist, the attribute of life is restricted to one anatomical element alone, and this homogeneous and structureless; while all the rest of the infinite variety of structure and composition, solid and fluid, which make up living beings, is merely passive and lifeless formed material. This distinction into only two radically different kinds of matter, viz., the living or germinal matter and the formed or lifeless material, gives the clue whereby he clears up the confusion into which the cell-doctrine had fallen, and gives the point of departure for the theory of innate independent life of each part, which the cell-theory had aimed at, but failed to make good. The one true and only living matter—called by Beale germinal matter, or bioplasm—is described as 'always transparent and colorless, and as far as can be ascertained by examination with the highest powers, perfectly structureless; and it exhibits those same characters at every period of its existence.' * * *"

"The name of bioplasm," continues Drysdale, "given by Beale, or protoplasm, as indicating the ideal living matter, cannot be given to any substance displaying rigidity in any degree: nor to anything exhibiting a trace of structure to the finest microscope: nor to any liquid: nor to any substance capable of true solution. Thus 'nothing that lives is alive in every part,' but as long as any individual part or tissue is properly called living, it is only so in virtue of particles of the above-described protoplasm, freely distributed among, or interwoven with the textures so closely that there is scarcely any part, $\frac{1}{500}$ of an inch in size, but contains its portion of protoplasm. Thus we see realized the

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[1] Monographie der Moneren," *Jenaische Zeitschrift f. Medicin und Naturwissenschaft*, 1868, iv, 1; translation in *Quarterly Journal of Microscopical Science*, London, 1869, vol. ix, p. 223.

[2] *Loc. cit.*, 42, *et seq.*

hypothesis of Fletcher, that all living action is performed solely by virtue of portions of irritable or living matter interwoven with the otherwise dead textures." The objection, however, urged by Bastian to Beale is so very pertinent, that it must also find a place here, but I shall not dwell upon other points on which Beale differs from the bioplasson doctrine; such as, that living matter exhibits the same characters at every period of its existence; and that it is always perfectly structureless. "It has always appeared to me," says Bastian,[1] "to be a very fundamental objection to Beale's theory, that so many of the most characteristically vital phenomena of the higher animals should take place through the agency of tissues—muscle and nerve, for instance—by far the greater part of the bulk of which would, in accordance with Dr. Beale's view, have to be considered as *dead* and inert."

In 1873, the morphological knowledge of living matter became exact. In that year, Heitzmann discovered the manner in which bioplasson is arranged throughout the body, and announced the fact that what had until then been regarded as separate form-elements in a tissue are really interconnected portions of living matter; that not only are there contained no isolated unit-masses in any one tissue, but no tissue in the whole body is isolated from the other tissues; and that the only unconnected particles of living matter are the corpuscular elements of liquids, such as blood, sperm, saliva, pus, etc., and so-called wandering corpuscles; so that, to use his own words: "the animal body as a whole is a connected mass of protoplasma in which, in some part, are imbedded isolated protoplasma-corpuscles and various not-living substances (glue-giving and mucin-containing substances in the widest sense, also fat, pigment-granules, etc.)." This announcement marked the commencement of a new era in biology.

Heitzmann discovered that the living matter as seen in an amœba is *not without structure*, as had, before his accurate investigations, been supposed; and that its structure, in all cases when developed, is that of a network, in the meshes of which the bioplasson fluid, or the not-contractile, not-living portion of the organism, exists. When there is a nucleus, it is connected by delicate threads with the extra-nuclear network; nucleoli and nucleolini inside of the nucleus, as well as granules outside, are portions of living matter: sometimes in lump, sometimes mere points of intersection of the threads constituting the intra-nuclear and extra-nuclear living networks, sometimes terminals of section of such threads, as first explained by Eimer,[2] and after this author by

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[1] The Beginnings of Life: being some account of the nature, modes of origin, and transformations of lower organisms. London, 1872, vol. i, p. 155.

[2] "Weitere Nachrichten über den Bau des Zellkerns." *Archiv f. mikrosk. Anatomie*, xiv, 1877, p. 103.

Klein.[1] Heitzmann discovered that what is true of the structure of bioplasson in the amœba, where a single small unit-mass of living matter constitutes the entire individual, is true also of the structure of bioplasson of all, even the highest, living organisms.

To be sure, much had been previously known regarding protoplasm or living matter, but the knowledge was fragmentary, until Heitzmann demonstrated not only that membrane, nucleus, nucleolus, granules, and threads are really the living contractile matter; but also, *first*, that this matter is arranged in a network, containing in its meshes the non-contractile matter, which is transformed into the various kinds of basis-substance, characterizing the different tissues of the body; and *secondly*, that the tissue masses of bioplasson throughout the whole body are interconnected by means of fine threads of the same living matter.

Unless these two facts of Heitzmann's discovery are accepted, there cannot be urged much against the continued use of the word "cell," misnomer though it be. Ranke,[2] after speaking of the "cell-wall," "cell-nucleus," etc.. says: "of these component parts of the cell, one or other may be wanting without the totality ceasing to be a cell. The nucleoli, the cell-wall, or the nucleus may be wanting, and yet we must designate the microscopic form a cell, or elementary organism." Drysdale thus comments upon this quotation, viz.: "if any one choose to describe a gun-barrel as a stockless gun without a lock, he is free to do so; but what good purpose can it serve? Or is there even any fun in it? The truth is, this clinging to the mere name of the cell-theory by the Germans seems to arise from a kind of perverted idea of patriotism and of *pietas* toward Schwann and Schleiden." But I think Tyson[3] has the better of the argument, in saying: "the word "cell" has become so intimately associated with histology, that it is doubtful whether it will ever fall into disuse, nor does it much matter, so long as correct notions of the elementary part are obtained." Now, if there were any separate and distinct "elementary part," it certainly would matter little or nothing whether it were called "cell" or by any other name, provided the name be properly defined and agreed upon. It is not against the name but against the idea of any isolated individualized form-element that the objection lies. Virchow maintains, "that the cell is really the ultimate morphological unit in which there

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[1] "Observations on the Structure of Cells and Nuclei," *Quarterly Journal of Microscopical Science*, Jan., 1879, p. 128. "The intranuclear as well as the intracellular network having, of course three dimensions, includes fibrils that lie in the two dimensions of the plane of the field of the microscope, as well as fibrils placed vertically to it. The former appear, of course, as fibrils; but, I should like to ask, as what do the latter appear, *i. e.*, those situated vertically. Clearly as dots, because they are seen endwise; and for obvious reasons most of them lie in the nodes of the network."

[2] The Cell-Doctrine; its history and present state. Philadelphia, 1878, p. 128.

[3] "Physiologie, 1872," quoted by Drysdale, *loc. cit.*, p. 104.

is any manifestation of life, and that we must not transfer the seat of real action to any point beyond the cell."[1] Against this statement nearly every author nowadays protests, and insists that vital power must be transferred from the "cell" to "living matter"; yet, after all, the disagreement, though ever so strenuously declared, is a mere verbal one: so long as both parties hold that "every higher animal presents itself as a sum of vital unities"—no matter what these unities are called or how defined. Hæckel, one of the most avowed advocates of "the protoplasm or sarcode theory," clings to Virchow's politico-physiological comparison, that every higher organism is like an organized social community or state, in which the individual citizens are represented by the "cells," no matter how he may define these, each having a certain morphological and physiological autonomy, although on the other hand interdependent and subject to the laws of the whole. Heitzmann's views necessitate the comparison of the body to a machine, such as a watch or a steam-engine, in which, though there are single parts, no part is at all autonomous, but all combine to make up one individual. Even Huxley, the popular champion of protoplasm as the physical basis of life, quite recently delivered an address, before the International Medical Congress in London, August 9, 1881, in which he used the following language: "in fact, the body is a machine of the nature of an army, not of that of a watch, or of a hydraulic apparatus. Of this army, each cell is a soldier," etc., etc. According to Hæckel and Huxley, the body is composed of colonies of amœbæ; according to Heitzmann the body is one complex amœba. I am very anxious to really make the difference between the cell theory and the bioplasson theory clear to every one of you. The essential point of the cell theory is the idea, that the body and each tissue of the body, every plant, and every animal, is made up of a number of distinct units; and the essential point of the bioplasson theory is the idea, that all the masses of living matter of each tissue of plants and animals are uninterruptedly connected, and that every tissue is connected with every other tissue by filaments of living matter. To accept Mr. Huxley's comparison, we must imagine that every soldier is indissolubly connected, hand and foot, with every neighboring soldier of the solid army!

There is no better test of the truth of the bioplasson doctrine than the structure of hyaline cartilage. If hyaline cartilage consisted, as "is generally believed," of "a homogeneous ground substance, in which are closed cavities harboring the corpuscles," the bioplasson doctrine would certainly be erroneous. If it merely contained lymph, or juice-channels, no matter what their character, whether open or

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[1] Die Cellularpathologie in ihrer Begründung auf physiologische und pathologische Gewebelehre, Berlin, 1858, p. 3. (Translation by Chance, London, 1859, p. 3).

closed, whether lined or unlined, whether in "homogeneous basis-substance," or "between layers of cells," or "in cement-substance,"[1] then, too, the bioplasson doctrine would be erroneous.

But the result of my observations, especially those illustrated in figs. 2, 3, and 4, admit of but one interpretation, and that an interpretation favorable to the bioplasson doctrine. It is unnecessary to more than mention that although I have placed on record so few, I have made many different examinations, under many different circumstances, and with varying powers of amplification. I need occupy myself here with only the two fields drawn in figs. 3 and 4, with an amplification of 600 and 1200 respectively. The remarkable specimens from which they are taken show more conclusively than it was ever before shown what the structure or constitution of hyaline cartilage really is. I think I have explained this sufficiently, but its full significance appears in its corroboration of the bioplasson doctrine.

To be able to uphold the cell-doctrine, cartilage would have to be, using a homely comparison, like a cake composed of hard dough with raisins. No matter how widely we may extend the definition, to remain within the boundary of the cell-doctrine this metaphor must be applicable. Innumerable painstaking researches have led to various modifications of notions entertained regarding the structure of the two constituents of the cake and their relation to each other. It may be seen by the most recent publications on the subject, that the acceptation of the existence in the dough of cleavage in certain directions, of interlaminary and interfibrillar spaces, and of offshoots, even ramifying prolongations of the raisin-substance, or, at all events, of an ingredient of the raisins, is held to be not incompatible with the cell-doctrine. If, however, we can represent cartilage as a filigree or framework of raisin-substance, in the meshes or interspaces of which framework blocks of dough are imbedded, certainly the fundamental view of the ultimate construction of the tissue is changed, and we are no longer in accord with the cell-doctrine, even though we be inclined to use that term in the widest possible sense. Look for a moment at the two illustrations on the blackboard, as well as at figs. 2, 3, and 4. The upper figure represents a section of cartilage stained with gold chloride.

This, as I have already explained, stains the living matter and leaves the basis-substance unstained. High powers exhibit the appearance, etc., etc. In regard to a name as a substitute for the term "cell," I would say that all corpuscular masses may be called, simply, corpuscles

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[1] These statements of the general belief are quoted from the introductory paragraph of Thin's memoir, "On the Structure of Hyaline Cartilage" (*Quarterly Journal of Microscopical Science*, xvi, 1876), in which Thin's own views are laid down to the effect "that layers of cells epithelial in arrangement exist in the substance of cartilage," "that both the stellate and the parallel systems of lymph-channels exist," etc.

—thus we may speak of blood-corpuscles, pus-corpuscles, etc. For all the accumulations of living matter within the ordinary fields of basis-substance, but more especially for those smaller masses which, having as yet developed neither a network structure nor much vacuolation, are still homogeneous, or nearly so, I am quite willing to adopt either the designation of "plastids," proposed by Hæckel, or that of "bioplasts," proposed by Beale. Perhaps it would be well to restrict the word "bioplast" to a small mass of living matter exhibiting no differentiation, and distinguish from it as "plastid" the larger mass showing an interior structure more or less like the fully developed corpuscle. Thus, I would always use the term "plastid" in the place of "cell."

The result of my investigations as to the structure of cartilage is that in this tissue, beyond the possibility of a doubt, the living matter is arranged in the form of a network, containing in its meshes the non-contractile matter. How is it with regard to the other proposition of the bioplasson doctrine, viz., that the living matter of the different tissues is interconnected? Examinations with high powers of such a specimen as that represented in fig. 1, showing the perichondrium of horizontal sections through the larynx, or the neck, with skin and more or less of other tissues included, enable me to answer this question to the effect that fine filaments of living matter pass from one tissue to another in connection with the network of living matter in each. The details of these examinations are reserved for another time. But it has been suggested to me that I ought not to conclude without saying a few words as to the practical advantages of the Bioplasson Doctrine over the Cell-Doctrine. Every exact scientific investigation, even though at first of theoretical value only, sooner or later brings with it some practical benefit; and this doctrine of living matter, aside from the satisfaction which the perception of abstract truth grants—lying as it does at the foundation of our knowledge of living things—has advanced their physiology and pathology at every point. In practical medicine it has already aided us in so many ways that their merest enumeration would require another hour's lecture. We know that the disposition of living matter is different in different persons, and that in the case of increased supply of food the reaction is different in strong and healthy people from that in the sick and weak. Upon this knowledge rests, to-day, the *whole doctrine of pulmonary consumption.* Now, the amount of living matter within the same bulk varies greatly both in normal and morbid conditions. A small lump of bioplasson in the urine or expectoration, taken from an individual of good constitution, will show a close network with coarse granulations, or perhaps be almost homogeneous-looking under the microscope—owing to the large amount of living matter in the small bulk: while a plastid, from a weak, broken down or phthisical person, will be finely granular and exhibit a network with large meshes on account of the relatively small amount of living matter in it. Sometimes we thus, from the examination of a drop of blood, gain an insight into the condition and vital power of the whole individual; sometimes, recognize a disease before it is sufficiently developed to do much harm, and thus come a step nearer to the highest aim of the physician—the prevention of disease.

DISCUSSION.

Dr. B. N. MARTIN remarked on the great value and important bearing of this investigation.

Mr. A. H. ELLIOTT enquired whether the blocks of non-living matter in the cartilage were entirely separated.

Dr. ELSBERG explained that the blocks were separate, their only connection being the interposed threads of the *reticulum* of living matter; and to the former is due the opalescent character of hyaline cartilage. He further stated that the condition of health of an individual might be inferred in a degree from a study of the character of the network, a thin section of a very minute portion of the body often showing a difference of network in different persons, *e. g.*, in the thickness of the threads, the size of the meshes, the character of the points of intersection, etc. From the uniformity in the size of the meshes, etc., or from their variability, or from the proportion of corpuscles presenting a normal and abnormal character in their network, a good or bad prognosis was deduced by the physician, and even an indication of the progress of disease.

Prof. E. H. DAY referred to the wonderful character of protoplasm in its wide results in the construction of the most varying textures in the vegetable and animal kingdoms. The speaker's observations have brought the protoplasm of cartilage tissue into correspondence with that in the tissues of the sponge, of the plant, and all the lower forms of life. In protoplasm we are brought face to face with the most astonishing substance in nature.

Mr. J. D. WARNER offered objections to the vague views of Virchow on the soul of the cell and its relation to the soul of the individual.

Dr. NEWBERRY said that, having been educated as a physician, and having studied microscopic anatomy under Dr. Charles Robin, he had followed with great interest the progress of modern research into the ultimate structure of organic tissue, and the discussions of the origin and seat of vitality to which it has given rise; and he regarded such investigations as those of Dr. Elsberg as of the highest scientific interest and practical value. If we ever learn the causes of malarial and infectious diseases, or the cure of the morbid growths which are the scourges of humanity, cancer and tubercle, it will be through such researches. But he thought that much of the discussion which had been excited by these investigations had been irrelevant and confusing, especially that in regard to the seat and nature of life, into which microscopists and chemists had entered with great earnestness and some acrimony, but with no satisfactory result. In this discussion some writers had made the ultimate cell the seat of life, and had glorified and almost deified it. Others claimed that the cells were only portions of a general vitalized and automatic tissue; while others still contended that the phenomena of vitality were the mere manifestations of chemical changes taking place in structure otherwise lifeless.

With none of these views could he sympathize, as there had really been no approach to an end in the effort to localize or analyze life. Unless we accept the materialistic theory of spontaneous generation, advocated by Dr. Bastian, but rejected by most biologists, we must confess that no more is now known of the origin, nature and seat of life than was known to Aristotle. All we have done is to acquire a better knowledge of the *machinery* by which the functions of life are accomplished; most important knowledge truly, since it enables us to distinguish between normal and morbid life action in the tissues where this action begins, and promises to point the way for promoting the one, and preventing the other—but limited to the methods in which the life force acts, not reaching the inscrutable and intangible force itself.

The work done by a microscopic cell is wonderful and incomprehensible to us, yet all cells work not as independent individuals, but as members of a community, and for a common end. For example, the terminal cell of the fibril of a plant root is a delicate vesicle—the cell in its simplest form, and yet when new born, and having existed but the fraction of a minute, it begins its special work of supplying certain food elements to the plant above; and this it does with a discrimination which is infallible. Water it absorbs by endosmosis, and, when deficient, begets progeny to send for it. It also appropriates other things that are necessary to the growth of the plant to which it belongs, whatever that be; if tobacco, an unusual quantity of potash; if grass, of silica. It always works to a pattern determined by the character of the plant whose general economy it serves, and is controlled by the influence which gives to that plant its special and recognizable leaf, flower and fruit, its noxious or alimentary qualities. So in all other parts of the structure the cell is doing its allotted work in a community of which it forms an integral part. It is therefore in no sense an independent individual. Our notions of what constitutes an individual or a community may seem to us quite clear, but they are in fact likely to be somewhat confused. Every man recognizes and asserts his own individuality, but we all know that men who live in communities often think and feel as one though many. A great grief crushes all alike, a great danger rallies all in defence. The social insects, ants and bees, retain their corporeal individuality, but are curiously linked together in a common life that makes each but a part of a whole. A tree is universally accepted as an individual, but, as all know, it may be divided to form an unlimited number of perfect trees which expand this individual into a forest and prolong its life indefinitely. The sponge is said to be a community of amœboid individuals, but these share a common skeleton, fashioned for the wants of all, and all unite in the general function by which the inhalent and exhalent currents are maintained, a function on which the life of all depends. In the corals which live in communities, we find the common skeleton covered with a vitalized gelatinous integument on which are set here and there the individual polyps. These live to a great degree each for itself; each throws out its tentacles and forages for its own support, but at the same time it shares a life with its neighbors; an injury done to one affects those about it, and a misfortune involving a sufficient number destroys the life of the colony.

The elusive and intangible nature of the life which pervades plant tissue is well shown in the growth and decay of a tree. From a microscopic germ a young *Sequoia* springs into existence, and for a thousand years or more lives its life. All this time it is inspired by a power which acts in antagonism to the affinities of inorganic chemistry in opposition to the force of gravitation, and which builds up a mass hundreds of tons in weight, mostly obtained by the breaking up of one of the strongest bonds in chemistry, that of carbonic acid, appropriating the carbon and setting the oxygen free. Every part of the huge structure is pervaded by this peculiar creative and conservative influence; and every cell of root or stem or leaf contributes its part to the harmonious whole. At length the time arrives when this peculiar influence which we call life deserts the structure it has created. The affinities of inorganic chemistry now assert themselves, all the ephemeral fabric is rapidly disorganized, and soon a heap of ashes—the inorganic matter woven into its composition—alone remains to tell of its existence. Who can tell us what was the nature of the enchantment which created this Aladdin's palace—whence it came, where it dwelt during its sojourn, and whither it has gone? We may say it resided in the terminal root cells; but these are inseparably connected with the leaves, hundreds of feet above. The tie that binds them is a vital one; neither could live without the other, nor without the intervening chain which connects them.

By studying the anatomy of plants and animals, we obtain a knowledge of the organs and laws, as we call them, of animal and plant life;

that is, we get a knowledge of the machinery with which the functions of life are accomplished, a knowledge of the order and manner in which these functions are performed; but the *primum mobile*, the real "power behind the throne," remains as yet unseen and unknown to us.

November 28, 1881.

LECTURE EVENING.

The President, Dr. J. S. NEWBERRY, in the Chair.

The hall was filled to overflowing.

In introducing the lecturer of the evening, the President stated:

'Captain Cheyne asks you to examine his plans carefully. He has been with three expeditions to the Arctic regions, and has spent there five and a half years. He has been there under so many circumstances that he knows, perhaps better than any other man, the difficulties to be encountered and how to overcome them. He comes recommended by the highest authorities in England. His plan is not chimerical, and it is certainly heroic. Men will yet surely go to the Pole, if they have to crawl there on their hands and knees; and an enterprise of this kind is worthy of attention in these days, if only to withdraw the minds of men from their shops and money-getting and purely selfish occupations."

COMMANDER JOHN P. CHEYNE, R. N., F. R. G. S, then delivered the following lecture:

THE DISCOVERY OF THE NORTH POLE PRACTICABLE.

(Abstract.)

Reference was first made to the large number of local committees—sixty-two—and of influential persons in England who have signified their approval of this enterprise.

A Council has been formed in England and is now awaiting the news from America. As soon as it has heard of action taken here toward the formation of an Anglo-American expedition, the members of the Council will bestir themselves. It was originally designed, by means of an expedition, the cost of which would have been about £30,000, to include the circumnavigation of Greenland, besides the journey to the North Pole.

The following plan is proposed for reaching the Pole. A small vessel will be engaged to convey the exploring party, with provisions for two years and a half, to St. Patrick's Bay, near Discovery Harbor, leave them there, and immediately return. The party will consist of seventeen persons all told, including Lieut. Schwatka, U. S. A., the commander of the late American Franklin search expedition, who has most cordially volunteered to accompany this party, on the part of America.

To attempt to reach the Pole in the usual manner, there would be required six sledging parties of five men each. Each man would have to drag 215 pounds. The Lecturer believed that the journey could be performed by means of sledges, as he had not the most remote idea that there is an open sea about the Pole. Starting in April or early May with the six sledges, they would go fifty or sixty miles on the journey; and then sledge No. 6 would stop and bury in some safe place all its spare supplies, as a depot for the return journey, and that sledge would return to the ship. After going fifty or sixty miles more, the fifth sledge would stop in the same way, bury its spare provisions, and return to the ship. The first sledge would keep on until the Pole was reached. In this way the journey might be made in 106 days, but would be far more difficult and laborious than that proposed by the following plan.

On arrival at St. Patrick's Bay, three snow observatories will be established, one situated in the immediate vicinity of the coal mine, at St. Patrick's Bay, another fifty miles further north, and the third the same distance to the south. These observatories will be connected by telegraph wires, and hourly meteorological observations will be taken and transmitted to the central station. Thus accurate information as to the direction and force of the wind, simultaneously over a distance of one hundred miles, will be obtained and immediately plotted at the central station. When the proper wind curve for reaching the Pole is found to exist, the attempt will be made by means of balloons. These will be of large size, and three in number, costing altogether about £12,000. Each will carry three men, be provided with a boat car, a set of Esquimaux dogs, and provisions for fifty-one days. The total load for each balloon will be between one and one-half and two tons. The gas for inflating the balloons will be generated, at least mainly, from the abundant coal at this harbor, and, to prevent the too rapid diffusion and loss of gas, it is proposed to employ a double envelope of silk with an intermediate layer of gold-beaters' skin. It has not yet been decided whether to use pure hydrogen or a mixture of coal gas and hydrogen. The Commander has convinced himself by experiments with balloons, both in polar regions and in England, that they can be satisfactorily used in the way above proposed; and he hopes to cover the distance from St. Patrick's Bay to the Pole, 496 miles, in from eighteen to twenty-four hours. The altitude of the balloons will be regulated at about one thousand feet by means of a trail rope.

After arrival at the Pole, advantage will be taken of a favorable wind to return to St. Patrick's Bay, or, possibly, to continue in one balloon right on to some part of Russia, should it appear better to take that course. Any loss of gas during the balloon trip, which may be found to have occasioned a deficiency on arrival at the Pole, or during a short stay there for scientific observations, may be remedied by the abandonment of one balloon and the transference of its gas into the other two, and, possibly, by the conveyance of a small supply of hydrogen in steel cylinders.

Many interesting arctic phenomena were discussed: *e.g.*, the proofs that the aurora borealis was not caused by atmospheric electricity but by magnetism: the numerous parhelia and mock moons visible in polar regions: the mode of formation of glaciers and icebergs, and the curious shapes assumed by the latter.

The coal of the mine at St. Patrick's Bay was described as equal to the best Welsh, almost smokeless, and existing in very large quantities. The present meagre flora of Greenland was compared with the rich ancient flora, almost tropical in character, shown by the fossil plants found in the Tertiary beds of the vicinity of Disco. More than fifty species of trees and shrubs have been obtained from these deposits.

In conclusion, the Lecturer spoke of the very probable success of the proposed Anglo-American expedition now being organized by Lieut. Schwatka and himself, and stated that the estimated expense, at a minimum, is to be £16,000, each country to provide half of this sum, and all discoveries to be equally shared by the two nations. The Commander laid great stress upon the good feeling existing between America and England, expressing the opinion that the organization of such a joint expedition as proposed, especially if the two national flags were to be planted side by side at the world's apex, would so materially develop that feeling, that therein would be at once an answer to those questioners who asked "*cui bono*? What commercial return can we expect for our expenditure for equipment?" Further utilitarian achievements were then touched upon, as relating to the more thorough study of the sea-bottom by soundings, and of the oceanic currents within the Arctic circle, so that in time commerce will be enabled to work out more definite highways for the passage of ships across the ocean; also to the development of knowledge in different branches of science, in addition to the advantages that might accrue in opening up and investigating such a vast unknown area.

At the conclusion of the lecture, the audience expressed, by a show of hands, its hearty interest in the subject, after the delightful mode of its presentation and illustration by Commander Cheyne, and its recommendation of the matter to the careful consideration of the public.

Dec. 5, 1881.

REGULAR BUSINESS MEETING.

The President, Dr. J. S. NEWBERRY, in the Chair.

Twenty six persons present.

Dr. NEWBERRY exhibited an ancient perforated stone axe from Europe, consisting of dioryte, and remarked that the aboriginal tribes of America never attained to the degree of skill required in the perforation of stone implements for the insertion of wooden handles.

The following paper was read by Dr. ALEXIS A. JULIEN.

THE VOLCANIC TUFFS OF CHALLIS, IDAHO, AND OTHER WESTERN LOCALITIES.

(*Abstract*).

In a paper recently read before the Academy it was shown that a certain compact white almost structureless rock, often porcellanous in texture, occuring abundantly in the Western Territories, and variously styled "trachyte," "rhyolyte," "porphyry," etc., (*e. g.*, at Leadville, Colorado, in the Black Hills of Dakota, etc.), is a sedimentary form of a highly silicious volcanic tuff, probably derived from the finest detritus of trachytes, rhyolytes, and quartz-porphyries. A series of specimens collected by Prof. NEWBERRY, during the last and previous summers, and kindly put in the author's hands for lithological examination, has furnished the material for the following additional notes on this interesting but neglected group of widespread American rocks.

1. *Coarse pumice-tuff of Challis, Idaho.*

The rock is quite compact, schistose, of a gray color with dull white spots. The latter consist of pumice in finely fibrous grains, from 1 to 5 mm. in length. Quartz and feldspar are seen in small angular flakes, sometimes reaching 0.5 mm. in length: hornblende commonly in fibrous black fragments, about 1 mm. in diameter: and much biotite, brownish-green, sometimes brownish-black, with greasy lustre, in hexagonal scales, often up to 2 to 3 mm. in size.

The thin sections present under the microscope numerous grains, generally angular, of several minerals, varying in size up to 3 or 4 mm.: pumice in rounded to sub-angular fawn-colored fragments lying at all angles, commonly made up of straight or curved fibres, and often including glassy lenses filled with crystallites: a triclinic feldspar, in clear grains, sometimes including minute globules of glass, and possessing fine lamellation, beautifully striated in polarized light, the remaining traces of crystalline outlines indicating that these grains are all of fragmentary, never of indigenous formation: quartz, in water-clear angular grains, 0.2 to 1.6 mm. long, retaining more frequent and perfect traces of their crystalline forms, their sides being often very ragged, curiously and deeply eroded into rounded indentations, while within occur numerous inclusions of the ground-mass and of scales of biotite, long greenish needles of hornblende, and sub-angular drops of a brownish-violet glass with one or several fixed bubbles of gas: biotite in abundant irregular scales, 0.2 to 1.3 mm. long, brown inclining to maroon or brownish-yellow, cloudy to opaque, with some dichroism remaining in the striated sections; hornblende in brownish-green, strongly dichroic, fibrous crystalline flakes: opacite, probably magnetite, and ferrite or iron-oxide, in dusty particles or groups in the biotite scales and among the pumice fibres. The fine ground-mass is mainly composed of minute fragments, fibres, scales, etc., of all these minerals: also in large part of solid globules of fawn-colored glass, or of thin and apparently hollow shells, or of fragments of quartz or feldspar coated with a glass crust. Many of these forms are found adhering in curious aggregations or with their sides crushed in.

The general constitution of this rock is similar to that of the volcanic tuff of the El Dorado Cañon, Cal.

2. *Fine green volcanic tuff, of Challis, Idaho.*

A very fine compact rock, with almost the texture of stoneware, with a pale, greenish-gray color, and a very thin parallel lamination. A few minute scales of biotite can be distinguished by the loup. The surfaces of fissures are mottled and spotted with bluish-green and ochreous, brownish-gray films.

The thin sections present the same constitution as that of the coarse variety of the rock, without the presence of pumice, the particles of quartz and feldspar varying in size from 0.06 to 0.25 mm. Biotite is abundant in scales 0.1 to 0.2 mm. in diameter, often of ochreous shades of brownish-yellow and maroon, through partial decomposition, and with curved fibres or wrinkles as if crushed in by pressure. To its abundance are due the fine lamination of the rock and, in part, its greenish color. The ground-mass largely consists of globules of colorless glass, but in less degree than in the preceding variety, their size varying from 0.006 to 0.01 mm.

3. *Fine white pumice-tuff, of Challis, Idaho.*

A very fine compact rock, grayish, with a bronze shade, with a lamination so decided that it inclines to slaty. Under the loup the same constituents are visible as in No. 1.

The thin sections show a close relationship to those of No. 2. A little hornblende is present. Biotite occurs in distinct scales, sometimes hexagonal, not so minutely dispersed as in No. 2, generally 0.01 to 0.1 mm. in diameter. The fragments of quartz and feldspar, as a rule, present their longer axes in the schist-plane, varying from 0.03 to 0.22 mm. in length. The glass inclusions in the quartz, range from 0.002 to 0.037 mm. The ground-mass appears to be mainly composed of pumice, more or less altered, in very minute fibres and particles.

This rock strongly resembles the tufa of the lignite beds near Osarisawa, Akita, Japan.

4. *Pumice-tuff, Moore Station, Pancake Range, Moray, Nevada.*

This rock is decidedly schistose, cream-colored, nearly white, of a fine grain, intermediate between Nos. 1 and 2, most of the constituents being the same as in No. 1 and less than 0.5 mm. in diameter, though occasional grains of pumice, gray and red obsidian, and perfect crystals of quartz, may reach from 2 to 8 mm. in length.

In the thin section the constituents are found disposed with great regularity: pumice, with its fibres often curved, as if crushed while still soft and plastic: quartz: triclinic feldspar, possibly sanidine: magnetite: ferrite: biotite, salmon-colored, sometimes very cloudy: and volcanic glass in cellular network, often full of gas bubbles, elongated and distorted. In the ground-mass, globules of glass and fibres and threads of pumice largely predominate.

The pumice in all these tuffs is not perfectly isotrope between the crossed nicols, but presents innumerable, though exceedingly minute glittering points, apparently crystallites formed by incipient devitrification. A few minute sphærulites were also detected.

5. *Stratified Rhyolye-tuff, Tempiute, Nevada.*

A snow-white kaolinic variety, related to the preceding, which appears to consist principally of pumice. A few grains of black obsidian and red quartzite occur, the latter also as a somewhat rounded pebble, 34 mm. in length.

The thin section, transverse to the schist-plane, presents an interesting structure, made up of granular layers alternating with others possessing strong fibration.

The material of the former is mostly like that of No. 4: feldspar is sparsely scattered: quartz fragments abound, with the usual glass inclusions, and with sides deeply eroded and indented: also magnetite, ferrite, and minute colorless particles of a polarising mineral, perhaps Augite, in a predominant ground-mass of particles and fibres of pumice and glass, rich in dark gas-bubbles.

The alternating fibrous laminæ consist of a true rhyolyte material, salmon-brown, with a marked fluidal structure around the few quartz-grains, and displaying in spots, and especially next the junction with granular material, the constituent pumice-fibres whose partial interfusion or cohesion seems ordinarily to have produced the solid laminæ.

The arrangement of the glass fibres in parallel planes may have been produced by sorting in the air during their fall, or by later superincumbent pressure while still hot and plastic, or it may be in some instances by the influence of overflowing lava-sheets. The cohesion produced by such downward pressure and interfusion has produced a structure which can hardly be distinguished from that of many obsidians and rhyolytes.

6. *Fine white pumice-tuff, from mouth of Bill Williams' fork of Colorado River, Arizona.*

A compact white schist, with almost the fine texture of No. 3, traversed in places by brown curved impressions, apparently produced by rootlets.

The thin section mainly exhibits a very finely felted mass of short, straight fibres of pale brownish pumice. Besides these only a very few black particles of magnetite, feldspar, etc., were distinguished.

7. *Fine brownish pumice-tuff, from last locality.*

A brownish variety of the preceding, with abundant minute black particles. The slaty lamination is decidedly marked, with slight adherence over many planes at which the rock breaks easily, presenting remarkably flat surfaces.

The constitution displayed in the thin section is similar to that of the preceding specimen. Minute glass globules are abundant, and also more numerous angular particles of other minerals: colorless feldspar (sanidine?) showing cleavage: brownish and greenish augite: brownish and dichroic fibres of hornblende, and black particles of magnetite.

8. *Stratified pumice-tuff, from Black Mountains, Colorado river, Arizona.*

A coarser stratified tuff with brown and white layers, in which grains of pumice, obsidian, glassy feldspar, and quartz reach a diameter of 1 to 5 mm.

The thin section is rich in pumice in all its fibrous, curving, and reticulated forms, and in minute globules, threads, and shreds of volcanic glass: angular grains of finely lamellated plagioclase, water-clear quartz, and sanidine with well marked cleavage and often zonal structure: particles of biotite, hornblende, magnetite and ferrite: abundant grains of augite, angular to rounded, sometimes retaining its optical characteristics in spots, but mostly decomposed and isotrope, colorless, brownish-yellow, light to deep maroon, etc., finely granular, thready, or fibrous, and more or less darkened by opacite even to complete opacity.

9. *Basalt-tuff, or peperino, Chinati Mts., Texas.*

A fine-grained olive-green rock, with white streak, friable to arenaceous, with barely perceptible schist structure in the specimen. Under the loup, minute granules of feldspar, quartz, etc., are distinguishable, rarely 1 mm. in diameter, embedded in a grayish-green cement.

In the thin section the constituents are very much the same as in No. 8, with the exception of hornblende, and all the grains are in large part rounded. A few elongated rounded grains of a basaltic lava are also included, highly microcrystalline with minute ledge of plagioclase scattered through a reddish-brown opaque base.

This specimen, and perhaps the preceding, represent the basic division of the tuffs, being ejections from an eruption of basaltic lava, though naturally composed of its more fluid, glassy, and acid scoria.

From these facts it may be concluded that enormous masses of volcanic tuffs of widely varying character are dispersed throughout these regions in the West, to an extent which could hardly be appreciated from the meagre references in our present petrographical literature.

In his discussion of the rhyolytes of the fortieth parallel, Zirkel remarks: *

"The foregoing descriptions show in what abundance those fibrous bodies in which the fibres are not grouped radially around a centre, as in sphærulites, but arranged axially along a longitudinal line, are disseminated through these rhyolites .... These axiolites usually consist of distinct, uniformly thin fibres, or of wedge-like particles.... We see in the arrangement of the fibres in these rhyolites four different types: *a*, centrally radial: *b*, longitudinally axial: *c*, parallel: *d*, confused and orderless. The development of fibres is, indeed, a phenomenon very characteristic of rhyolites, etc., etc."

A comparison of these facts with those presented in my examination of these tuffs, appears to me significant, not of the development of fibration, etc., in a fused mass, but of the fragmental origin of at least many rhyolytes, obsidians, etc., as suggested in the study of No. 5. The evidences of the hot and plastic condition of the fibres and drops of volcanic glass, with the occasional exception of a cooled outer shell, for a long time after their fall, and of a tendency to the growth of microliths, sphærulites, etc., within them, may offer another mode of origin for the formation of axiolites and sphærulites. The anomalous presence of augite in a quartzose rock like rhyolyte, to which Zirkel calls attention in the same passage, may also find explanation in the varied intermixture of minerals which prevails in many tuffs, rather than by indigenous development within an acid lava.

Dr. NEWBERRY said that he had no doubt that Mr. Julien was quite correct in regard to the genesis of the peculiar rocks which he had described. He had collected the specimens and was able to supply some facts in regard to their mode of occurrence. They belong to a series of rocks, plainly volcanic, but of which the history has not been given by those who have studied the volcanic rocks of the West. The circumstances of their occurrence are briefly these: over a great belt not less than one thousand miles wide in some places, viz., from the

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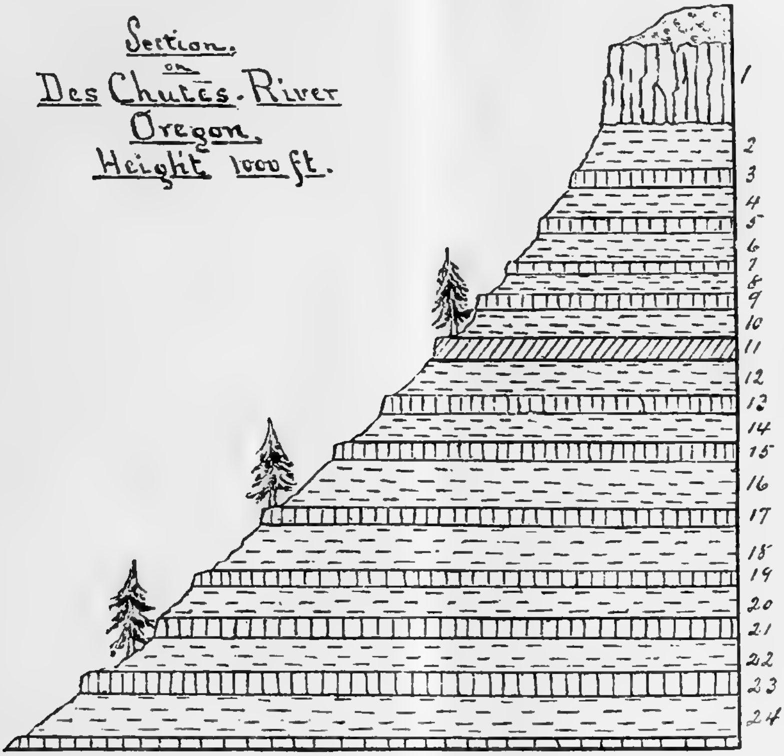
* U. S. Geol. Expl. 40th Par., VI, Microsc. Petrog., pp. 201-205.

crest of the Sierra Nevada to the eastern foothills of the Rocky Mts., and with a north and south extension of thousands of miles in British Columbia, the United States and Mexico, we have an extraordinary display of the products of volcanic action. This is the great silver belt of the world, and is also rich in mines of gold, copper, lead, etc. Throughout all the Paleozoic and Mesozoic ages this country was an unbroken, though not entirely unwarped, sub-marine or sub-aerial plateau, where the most continuous and extensive series of sedimentary rocks was deposited of which we have any knowledge. At the close of the Jurassic age the western portion of this region was folded up, to form the great chain of the Sierra Nevada and Cascade Mts., and along this line of fracture numerous volcanic vents were established, Lassen's Butte, Mt. Shasta, Mt. Hood, Mt. Baker, etc., which have continued in intermittent activity to the present day. In Tertiary times the plateau east of the Sierra Nevada was broken up by a series of north and south fractures, resulting in the formation of the remarkable system of meridional mountain ranges which constitute the chief topographical features of the district. These mountain ranges are composed of blocks of Paleozoic limestones and sandstones—now converted into marbles and quartzites—set up on edge or at a high angle,—or of volcanic materials which have welled up through some of the fissures. Along the lines of fractures are great numbers of hot springs, the representatives of thousands more which existed in former days, and to which we owe the great system of fissure veins of this country :—hot water charged with mineral matter gradually depositing this and filling the channels through which it flowed.

The volcanic rocks which have been poured out in so many places exhibit a great variety of physical and chemical characters, but have been grouped by RICHTHOFEN and ZIRKEL into five species—propylite, rhyolite, trachyte, andesite and basalt. Capt. DUTTON, who has given great attention to the volcanic rocks of the West, has distinguished a larger number of kinds and has adopted a different classification. Aside from these massive rocks there is another group which constitutes a marked feature both in the topography and geology, and these are those which have been made the subject of Mr. JULIEN'S paper. They are generally soft in composition, often highly colored,—white, red, blue, green, gray or yellow—more commonly white, red or gray. They are often quite local and usually occupy the lowlands, frequently underlying much of the level surface between the mountain ranges; and their best exposures are seen in the banks of streams which have cut these lowlands. There they are shown to be often horizontally bedded and sometimes interstratified with lacustrine sediments and sheets of basalt. Typical exposures of these rocks may be seen at Eureka, Nevada, where houses and cellars are excavated in the soft material which forms the sides of the valley; at Challis, in the banks of Salmon River and Garden Creek, whence the specimens described by Mr. JULIEN came, and in the cañons of the Des Chutes and its tributaries in Oregon.

Economically these rocks have considerable importance, as they are extensively used in place of fire-brick for lining lead-smelting furnaces, being very refractory, and easily dressed into shape with an old axe.



The above section represents the filling of some of the fresh water lakes which formerly existed in Oregon just east of the great volcanic cones of the Cascade Mountains. Numbers 1 and 11 represent sheets of basalt, the even numbers softer tuffs and bed of diatomaceous earth, the odd numbers consolidated conglomerates of volcanic materials called "concrete" in my notes.

The study of a large number of outcrops of this series of rocks from Southern Arizona to the Columbia River, has convinced me that they are generally volcanic ashes which have been washed down and more or less perfectly stratified in bodies of water which formerly occupied the intervals between the mountain ranges of the great basin. On the Des Chutes a section of more than 1000 feet shows 25 alternations of strata, many of which are examples of the rocks in question. Here they are interstratified with beds of tripoli, composed of fresh-water diatoms, and layers of basalt. Some of the ash beds are almost entirely composed of lapilli of soft cottony pumice, others are finer, grey, red, white, etc., and contain the trunks of coniferous trees, and in some instances are pierced with holes which represent the stems of upright plants, thickets of which were buried by the descending showers or rapidly accumulating sediment of volcanic ash. Here the source of the materials is to be sought in the line of great volcanic vents which crown the summit of the Cascade Mountains, and from which, at intervals, were emitted either floods of lava, poured down on to the plain along the eastern border of the range, or showers of ashes which, borne inland by the prevailing westerly winds, fell on forest, savannah and lake, temporarily destroying animal and vegetable life, and forming, when falling or washed into water basins, strata which alternate with fossil-beds, the accumulations of quieter times. In other places these tufaceous deposits were washed from all the highlands into the valleys, forming local masses of considerable thickness without the intercalated beds mentioned above.

The accompanying section, copied from my report on the Geology of Northern California and Oregon (Pacific R. R. Report, Vol VI, Geology, p. 47), will illustrate the deposition of these tufaceous rocks in the lake basins where they are interstratified with the fossiliferous beds.

Dec. 12, 1881.

Section of Geology.

The President, Dr. J. S. Newberry, in the Chair.

Forty one persons present.

Mr. N. L. Britton presented

"Additional Notes on the Geology of Staten Island."*

Two wells have recently been sunk to a considerable depth on Staten Island, in the vicinity of Stapleton. One of these is on the property of Mr. J. J. Cisco, near the summit of the Serpentine hills; the section as given by the Superintendent of the Pierce Well-boring Co., who sank it, is as follows:

Glacial drift	50 feet.
Soapstone	150 feet.

The well is six inches in diameter, and sufficient water was obtained to make it a success.

The other well is at the pump-house of Bischoff's Brewery, some 500 feet east of the most eastern serpentine outcrop at the foot of the

* These notes are supplementary to the paper on this subject read by Mr. Britton on April 4, 1881. (Ann. N. Y. Ac. Sci., II, 161.)

hills. This has now (Dec. 1st) reached a total depth of 210 feet, and the boring is still unfinished. The section thus far has been as follows:

Glacial drift.. 80 feet.
Various kinds of tough hornblende schist, apparently
varying to serpentine............................130 feet.

As yet no gneiss nor granite has been reached.

An outcrop of clay occurs near Clifton, about three-fourths of a mile south of the Forts, near the southern edge of the terminal moraine; it has been found, by borings made by Mr. Charles Townsend, in excavations for cellars, to be at least ten feet in thickness, and of a light color.

The clay is probably of Cretaceous age, and if so, this is the most eastern point at which beds of that age are known on Staten Island.

Mr. W. T. Davis has recently observed a large fossiliferous boulder of Schoharie Grit on the shore at Brighton Point. The fossils have been submitted to Dr. Newberry, and the following species identified:— *Dalmanites anchiops*; *Orthoceras Pelops*, *Strophodonta hemispherica*, *Atrypa reticularis*; *Strophomena rhomboidalis*; a *Fenestella*; and *Zaphrentis prolifera*.

Glacial groovings have recently been noticed on the hornblende-rock which is exposed at tide-level on Brighton Point. Some of the grooves are at least one-quarter of an inch in depth, three inches wide and four feet long. Their bearing varies from N. 15° W. to N. 17° W.

Discussion.

Prof. D. S. Martin considered the specimen of so-called hornblende schist from the well-boring, not to consist properly of that rock, but to be partly hydrated—apparently a less altered condition of the rock which higher up gives us the soft, semi-fibrous serpentine of the island.

Dr. Newberry regarded the serpentine of Staten Island as probably a pseudomorphous condition of hornblende slate. It differs considerably from the mottled serpentine of New York Island, which is "verde antique"; that is, is composed partly of serpentine and partly of carbonate of lime, and is scarcely distinguishable from the Moriah marble, which is quarried at Moriah, Thurman, etc., in the Adirondack region. It is a peculiar rock, and one of the connecting links between the rocks of New York Island and those of northern New York and Canada. Taken together, these afford strong indications of the Laurentian age of the New York Island and Staten Island crystalline rocks.

Dr. Newberry further said that the accurate determination of the age of the rocks of New York Island, of Staten Island, and of those underlying the drift of Long Island, was in the highest degree desirable and important; and while he was satisfied that the former were Laurentian, and the latter Cretaceous, it was eminently desirable that unquestionable proof should be found of this, if it is true. At present no positive assertions could be made, and the duty devolves on the geological members of the Academy to rid the subject of doubt.

The fossils in the boulder referred to by Mr. Britton prove to have come from the Schoharie Grit. In its original condition this was a hard, compact blue limestone, but is here presented in a leached state, by the passage of waters containing carbonic acid, with a loss of its lime, color, and density. It was derived from northern New Jersey, to which locality a belt of this rock runs down from Schoharie county. Its transit by ice was effected without doubt through the valley of the Hackensack, which lies east of the Orange Mountains and west of the Palisades. This glacial movement is indicated by the direction of the striæ observed by Mr. Britton, as well as of those in the Hackensack valley.

Mr. A. A. JULIEN recalled the results of his lithological examination of the serpentines both of Staten Island and of Hoboken, presented before the Academy two years ago, in which it was shown that sections of all these rocks abounded in minute fragments of more or less altered amphibole. The conclusion then stated, that these serpentines must be certainly derived from hornblende schist, was confirmed by the interesting discovery of the latter rock, both in well-boring and on Brighton Point. Serpentines of the same general character and origin occur frequently throughout New York and Westchester counties. The mineral serpentine is also found in small quantity as a vein-deposit, not pseudomorphous, like the main mass, but presenting an amorphous material with banded vein-structure, associated with magnesite, dolomite, etc.; e. g., the marmolite of Staten Island, a translucent green variety found at Hoboken, and also at West 60th street on New York Island, etc. At all these localities the amphibole survives in a more or less altered condition ; e. g., the tremolitic talc schists and slaty tremolitic serpentines of Staten Island and Hoboken, the hydrous anthophyllyte and unaltered tremolyte rock of West 60th street, New York, the tremolitic amphibolyte of New Rochelle and Rye, in Westchester county, etc.

Mr. BRITTON confirmed the last remarks, by the statement that a stratum of material, strongly resembling the hydrous anthophyllyte of New York, had been struck at the bottom of one of the wells on Staten Island ; also that veins of mixed serpentine and calcite were observed at Stapleton, possessing a banded structure parallel to their walls. At that point the apparent thickness of the serpentine bed is 150 feet, but the crest of the hill is composed of talcose schist.

MR. W. LE CONTE STEVENS then read a paper on "THE MAMMOTH CAVE OF KENTUCKY."

He also exhibited specimens of the blind fish (*Amblyopsis spelaeus*), and blind crawfish (*Cambarus pellucidus*), and stereoscopic views of various points in the interior of the cave.

(Abstract.)

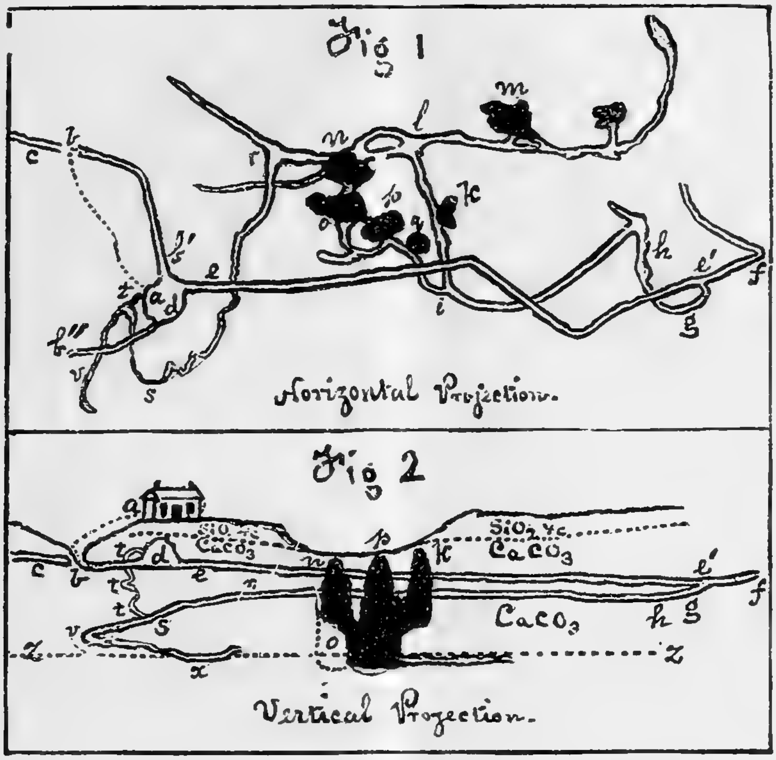
At the close of the Cincinnati meeting of the American Association for the Advancement of Science, in August last, he was one of a party of seventy-five members who visited the Mammoth Cave, remaining there two days, during which the greater part of the time was spent in exploration. He made no claim to new discoveries, but wished to call the attention of the Academy especially to recent observations, for the most part by Rev. H. C. Hovey, of New Haven, in regard to the temperature and structure of the cave. Mr. Hovey read a paper on this subject in Cincinnati, only a brief abstract of which has yet appeared in print, making use of a map, which is the first of its kind ever exhibited. The strictest precautions are observed by the authorities controlling the cave to prevent visitors from taking surveying instruments in with them: but the present manager, Mr. Francis Klett, has made a careful survey of the most interesting parts, and in time this will probably be given to the public, though possibly the scale of measurement may be withheld.

The central and right-hand portions of the map exhibited by Mr. Stevens had been enlarged by him from a copy of Mr. Klett's map. The left-hand portion was drawn only from recollection of the localities traversed, and not to scale, being intended only to illustrate principles. The same remark applies to the vertical projection, the lettering of which corresponds with that of the horizontal projection.

The temperature observations of Mr. Hovey were conducted with much care, and the very best instruments had been confided to him by the Director of the Winchester Observatory at New Haven. In August, 1881, while the external temperature at the neighboring hotel varied between 90° F. and 100° F., at points farther than 100 yards within the cave, the reading of the thermometer was never more than 56° nor less than 52½°, the mean temperature being 54° for the summer months. At a point 1,000 yards within, a thermometer had been left for six months, including the autumn and winter, and daily visited by Mr. Klett, who reported the variation to be only from 54° down to 53°. The underground temperature in this latitude, for points 60 or 70 feet below the surface, is usually assumed to be constant and about the same as the mean annual temperature above. According to Prof. Guyot's maps, the isotherm of 60° passes about thirty miles south of the Mammoth Cave, while that of 50° passes about forty miles north of Cincinnati. The temperature of the Mammoth Cave is fully 6° lower than has been commonly supposed, and may be taken as a fair representation of that of the crust of the earth in the country immediately surrounding it.

Mr. Stevens exhibited a geological map of Kentucky, showing the area of sub-carboniferous limestone in which the Mammoth Cave is situated. This is overlaid with a thin stratum, mostly of sandstone, that is pierced by thousands of sink-holes, through which the surface drainage is carried down into limestone fissures and thus to the general drainage level of the Green River. This stream passes at the distance of less than a mile from the Cave Hotel, the floor of the latter being 312 feet above the water and 118 feet above the mouth of the cave. He briefly explained, with a diagram, the general mode of cave-production in limestone strata, showing that subterranean tunnels must be started by the solvent action of slightly acidulated rain-water, and subsequently enlarged by erosion, along the fissures in the limestone. These agencies are still at work in portions of the cave, and the whole of this limestone country is thus honey-combed with caverns. No tunnel can be thus formed at any point lower than the general drainage level, since there must be an exit for the saturated water. The production of the fissures is referable to the general upheaval of this area at the close of the coal period: but, that there has been subsidence since the completion of much of the Mammoth Cave, is indicated by the fact that at its lowest parts to-day the floor is covered with water to the depth of thirty feet or more, having subterranean connection with Green River. The fissures intersect at various angles, but many of them are nearly or quite coincident with the dip of the strata, which is very gentle. Water passing through these forms the tunnels, while that passing through the vertical fissures scores out the pits which pierce them. The same pit, starting from a sink-hole at the surface, may have successively lower tunnels as exit passages. If the visitor encounters it while walking through the higher, and therefore older, tunnel, the upper part appears to him as a dome, the lower as a pit.

The rate of erosion in the Mammoth Cave has been variable. The older parts are perfectly dry, and entirely free from stalagmitic deposits, indicating rapid erosion, followed by elevation, so as to deviate the water completely into other channels. In the newer parts the water is still dripping from the surface above, and depositing stalactites and stalagmites; but as a whole the cave is by no means remarkable for these formations, being much surpassed in this respect by the neighboring White's Cave, of more recent origin. Those which do occur are moreover deeply colored with iron, which exists in the soil in the form of both oxide and sulphide. In the dry parts, the ceiling of the cave is more or less covered with efflorescent calcic, magnesic and sodic sulphates, which contrast with the iron-stained limestone, giving rise to the beautiful effects that have conferred celebrity on the opening known as the Star Chamber, and the myriad rock flowers of Cleveland's Cabinet.



The structure of the pits and domes was then illustrated with the aid of the accompanying map, by describing a journey through the cave. From the hotel, (*a*, figures 1 and 2,) the visitor walks to its mouth (*b*), by the side of a shallow ravine, terminating in what was formerly a large sink-hole. The door of this fell through, about seventy years ago, producing the present mouth of the cave, and cutting off part of the gallery, now known as Dixon's cave (*c*), which opens out near the Green river, a half mile distant. A walk of 1000 yards brings him to the Great Rotunda (*d*), about 170 feet in diameter and 100 feet high. It is immediately under the hotel, its roof being not more than 40 or 50 feet from the surface. Besides the gallery, called the Narrows (*b*'), by which access has just been obtained, another tunnel from the further side terminates in the Rotunda, to which the name of Audubon's avenue (*b*") has been given. The large, almost hemispherical opening, seems to have been cut out by the meeting of nearly opposite streams of water, which found exit, probably, through the main cave (*e*). At some distance within Audubon's avenue, a small opening in the floor is found, connecting it with the roof of the Mammoth Dome, a vast cavern

400 feet long, 100 feet wide and 250 feet high. These figures are of course only approximate, but it is believed that they are not exaggerated. Into this cavern the water is still trickling, and stalagmites are forming with sufficient rapidity to have cemented firmly to the floor a lamp dropped in 1812 and found in 1843. Returning to the Rotunda and passing through a half mile or more of the main cave, the visitor reaches, at *e'*, a large fallen slab of limestone to which has been assigned the title of "The Giant's Coffin." This makes the entrance to a side passage (*g*) which leads off to the lowest part of the present cave. The main cave forms an acute angle (*f*) and may be followed for several miles, terminating abruptly in a pile of rocks, where the roof has fallen in the same manner as at the terminus of Dixon's cave. Many of its side passages and avenues are yet unexplored.

Returning and entering the side passage near the Giant's Coffin, the visitor passes obliquely beneath the main cave, starting upon what is known distinctively as the Long Route. At an expansion (*h*) are successive deposits of gravel, sand and clay, indicating the downward course of the water which was here partially arrested. Some distance further on, the passage forks (*i*). Keeping to the right, the dangerous Side Saddle Pit (*k*) is encountered, which measures 65 feet in depth and 20 feet across. It is surmounted by Minerva's Dome, 35 feet high. The pit yawns across the right half of the floor of the tunnel, leaving a narrow path on the left. A short distance beyond (*l*), the tunnel again forks. Keeping to the right as before, Gorin's Dome (*m*) is reached, and may be viewed with the aid of magnesium lights, from a small opening on the side, ten feet above the pathway. The abysm extends 117 feet downward, 100 feet upward and 60 feet across. Leaving this and passing the fork (*l*), the tunnel is completely interrupted by the so-called Bottomless Pit (*n*) across which a bridge has been laid, resting upon a ledge. Despite its ominous name it does not defy measurement, having been found to be 95 feet deep on one side of the ledge and 105 feet on the other. Almost immediately overhead is Shelby's Dome, 60 feet high. Between the Bottomless Pit and the Side Saddle Pit are a pair of very large pits, discovered not a year ago by one of the guides, William Garvin, and examined for the first time last August by Mr. Hovey, who gave to them the names Scylla (*p*) and Charybdis (*o*) on account of the narrow, rugged passage which separates them and the great difficulty and danger of access. By timing the fall of pebbles into the water at the bottom, the depth of each was ascertained to be about 200 feet. Charybdis was seen to be directly connected with the Bottomless Pit. Indeed the latter may be regarded as only a part of Charybdis, its depth, 105 feet, being that of a jutting ledge, or the floor upon which water ceased to fall after being slightly deviated into

Charybdis, where the sound of its trickling is still audible. Shelby's Dome is simply the upward continuation of this combined pit. So narrow, moreover, are the ridges separating Scylla from Charybdis on the one side and from the Covered Pit, (*q*), on the other, and so small is the distance to the Side Saddle Pit (*k*), that it seems in the highest degree probable that this group of pits compose merely the upper branches of a single large pit into which they are all united, or at least directly connected before the bottom is reached, and the small relative depth of the Side Saddle Pit is explicable in the same manner as that of the Bottomless Pit. Such an extraordinary group of pits, forming an apparent nucleus of cave drainage, might be expected to have its counterpart in an unusually large depression, or group of sink-holes, at the surface. Impressed with this idea, Mr. Hovey found in the woods, scarcely half a mile from the Hotel, in the known direction of these pits, a depression (*p* Fig. 2.), many acres in extent, and so deep that from its edge he could overlook the tops of the pine trees that rose from the middle.

Leaving this region of pits and domes, the route leads still downward, passing again under the main cave through the narrow tortuous channel known as "Fat Man's Misery" (*s*) where the distance from floor to roof is in many places not more than three feet. Through the floor a winding passage has been worn away, varying in width and depth from one to three feet. This terminates in a chamber which has received the appropriate name of "Great Relief," where the succession of pebbles, gravel, sand and fine clay again records the work of erosion and deposit. This bed is not more than 50 or 60 feet above the drainage level, and from here down to the River Styx, the ground becomes more or less damp. A succession of bodies of water are then encountered, including the tubular Echo River, which is navigated in boats. It is a part of the tunnel which has subsided below the water level, and is in connection with Green River, being filled to within a few feet of the roof in summer, and completely closed in winter when the Green River rises. The column of air between the water and the impervious roof, closed everywhere except at the two ends, which are three-fourths of a mile apart, serves as a resonator for any note within the range of the human voice, and multiple echoes gliding imperceptibly into each other, continue to be returned for many seconds after the voice has been hushed.

Beyond Echo River, the cave may be followed with continual ascent, through Silliman's Avenue, the Pass of El Ghor and Cleveland's Cabinet, for about five and a half miles. A pile of jagged rocks, 100 feet high, is then surmounted and the wearied climber is confronted with a large cavern, 100 feet wide and 70 feet deep, where three short branches have united in one tunnel. Following the left branch for a few yards, a hall is found, in the floor of which is a pit 175 feet deep. The corresponding dome overhead is scarcely noticeable as such, for the surface of the ground is not more than 30 or 40 feet distant. The end of the Long Route has been reached.

In returning, the passage through Fat Man's Misery is avoided, and nearly two miles of walking are saved by climbing through a very steep, narrow, winding "Corkscrew" pass (*t*, Fig. 2), starting from the neighborhood of Great Relief and terminating at the side of the Great Rotunda. The vertical ascent is about 140 feet. To even stout-hearted mountaineers, if stout-bodied also, this Corkscrew is an intensified Fat Man's Misery, and upon them it rarely fails to leave strong and deep impressions, which may be of more kinds than one.

In regard to the animal life of the Mammoth Cave, conflicting opinions have been expressed by those who have made a special study of this subject. The bats, lizards and rats that have been found cannot be strictly called cave-dwellers, as they are always at points not so far removed from the outer light as to make this inaccessible. The cave crickets and blind crawfish have particularly long antennae and acute powers of hearing. Most of the crawfish are pale in color, some of them almost white; and this feature has been attributed to the continued absence of light. Crawfish, however, with well developed eyes and of dark color have been often found. These are without doubt either wanderers from Green River or the immediate descendants of such; and many generations of cave-dwelling are required to bring about such changes as have caused the application of a specific name, *Cambarus pellucidus*, to the white variety with only rudimentary eyes.

In regard to the blind fish it is a significant fact that the rudimentary eyes of the young are apparently less atrophied than those of the mature fish. Although to these cave-dwellers also a specific name, *Amblyopsis spelaeus*, has been given, they are by no means the only fish found amid this stygian darkness. The existence of fish with perfect eyes, apparently prospering where eyes are useless, shows how much less dependent these creatures are than more highly organized vertebrates upon approximate uniformity in external conditions. To those who have already accepted evolution, there is far less difficulty in believing that the colorless blind fish are the modified descendants of dark-colored ancestors with perfect eyes, which have wandered from Green River into Echo River, than in concluding that they have always constituted a separate species, as held by Prof. L. Agassiz, and subsequently contended by Prof. F. W. Putnam.* Nevertheless, Prof

*The Mammoth Cave and its Inhabitants. By A. S. Packard, Jr., and F. W. Putnam, Salem, Mass., 1879.

Putnam has shown that the differences between the blind fish *(A. spelaeus)* and their nearest living congeners are much more than in respect to mere color of skin and power of vision. Whether the internal anatomical differences on which he reasonably lays much stress can be proven to be a natural result of the external conditions imposed by cave life, is a question which, if settled at all, must be settled by zoologists alone. Prof. A. S. Packard, jr., and Prof. E. D. Cope are as pronounced in their opinion that the blind fish have been evolved from fresh-water ancestors possessing good vision, as is Prof. Putnam in the opinion that their ancestry were denizens of salt or brackish water, with which he believes that the cave was supplied at a time when this region was a salt or brackish water estuary. Prof. Putnam therefore concludes that the blindness of these fish is in no respect a consequence of subterranean life.

DISCUSSION.

Mr. BRITTON inquired whether any flora existed in the cave.

Mr. STEVENS replied that, so far as he was aware, no kind of vegetation had ever been found within it.

Dr. NEWBERRY remarked on the geology of the region adjacent to the Mammoth Cave. The limestone beds of this high table-land are jointed in the manner common to rocks, apparently by some sort of polarisation, producing fissures which run in a north and south, and an east and west, direction. The plateau is about 500 feet above the drainage, part of the drainage passing into the Green River, and part into the Ohio. No streams occur on the surface and the drainage is quite gradual. At the angle between these two rivers several streams are seen, bursting out of the cliffs at various heights above the Ohio; they are, so to speak, subterranean sewers, representing the underground drainage of the country; at one point three such streams pouring out of the rock form very beautiful cascades; and near Sandusky a full grown river flows out of the cliff of cavernous limestone. The beds consist of lower carboniferous limestone, with sandy layers beneath. In the vicinity occur portions of the great "blue grass region," one of the oldest parts of the continent, once an extensive highland, forming an island in the sea. Around this, rims of sediments were deposited, consisting of sandstones and limestones; while on the other hand, the continuous process of erosion, during the lapse of a vast period, removed the material of the table-land within, and converted it into a broad depression or basin, the "blue grass region," above which the present plateau of the encircling sediments now rises to a height of 500 feet.

The erosion of the joints in this plateau has resulted in the formation of the pits described by Mr. Stevens, but it is probable that some of these may reach 200 or 300 feet below the Ohio and Green Rivers. There is evidence, from borings in the Delta of the Mississippi, etc., that the continent was formerly more elevated, standing 500 to 600 feet higher at New Orleans than at present; the drainage was much freer, the Mississippi being a free flowing stream, as well as the Ohio and other tributaries. Borings have been sunk in the present trough of the Ohio river, to a depth of over 100 feet below its present bottom, without reaching the true bottom of the trough, the ancient bed of the river, which is perhaps from 100 to 200 feet further down.

Evidences of the same elevation of the continent were observed in caves on an island in Lake Erie. Long stalactites projected from the roof of a gallery whose end was ordinarily filled with water at the present level of the lake. At times a strong and steady wind has blown down the level of the lake and partially drained this gallery; but even then a guide, John Brown, resident on the island, has swum through the gallery and found the stalactites projecting from the roof as far as he could go.

In regard to the origin of the blind animals, the view of Prof. Cope is probably correct, that they have been derived from the degeneracy of ancestors that once had perfect eyes. No fish is formed with poor eyes; but any organ may be atrophied by disuse, with consequent feeble flow of blood, decreased nutrition, and inevitable shrinking of important parts. An analogy is shown in a comparison of the jaws of prehistoric and modern men. At present our "wisdom teeth" are useless, there is no room for them in the shortened under-jaw; our food being softened by cooking, cut up, and boneless, requires less vigorous mastication; and from disuse, and the consequently insufficient development, these teeth often speedily fall away. In the prehistoric man, on the contrary, the jaws were longer, roomier, supplied with more teeth—the "wisdom teeth" being well developed and kept in strength by constant use on coarse and rough food. The absence of the well-known stimulation produced by light, from the dark waters within the Mammoth Cave, has in the same way resulted in the atrophy of the organs of sight.

Mr. Stevens remarked in confirmation of this view, on the observation, first announced by Dr. Tellkampf, that the old fish found in the Cave have only rudimentary eyes, while in the young the eyes are simply imperfect, *i. e.*, the conditions tend to produce a reversion.

Dr. I. P. Trimble referred to his visits to the Mammoth Cave and its vicinity, the absence of fatigue in traveling within the Cave, and the occurrence of bats clinging to the walls at a point three-quarters of a mile from the entrance. He inquired concerning the condition of the eyes in the bats and crickets within the Cave.

Mr. Stevens replied that both species had eyes, externally and apparently perfect. However, the antennæ of the crickets were remarkably long, and seemed to guide them more than their eyes. He related observations made by Prof. Putnam on the crickets, and also on the crawfish from the Cave, shut up in an aquarium, which seem to indicate that they judge of their food more by touch than by sight.

DR. NEWBERRY had observed in an old Spanish mine in New Mexico, millions of bats clinging to the rock, many of them with their young, at a point several hundred yards from the entrance. In all cases such denizens of caves find ready access to the exterior atmosphere through the crevices and galleries.

MR. STEVENS had observed bats at the same distance from the entrance as noted by Dr. Trimble. In regard to the absence of fatigue in traveling underground, he had found a walk of thirty miles had caused no more exhaustion than one of ten miles on the surface; this was probably due to the purity, coolness and dryness of the atmosphere.

Mr. BRITTON stated that a *Natural Science Association* had recently been formed on Staten Island, having for its particular object the collection and diffusion of information on all subjects relating to the Natural History of the Island, and the formation of a cabinet illustrative of its natural products. The meetings are held at New Brighton on the second Saturday of each month. The officers of the Association are:

President.................................Sanderson Smith.
Corresponding Secretary,.... .. ..Arthur Hollick.
Recording Secretary,.....................Charles W. Leng.
Curator.......................... .....William T. Davis.

The address of the Corresponding Secretary is at Port Richmond.

December 19, 1881.

SECTION OF PHYSICS.

Vice-president, Dr. B. N. MARTIN, in the Chair.

Thirty persons present.

A specimen of acicular hornblende in quartz was exhibited by MR. W. L. CHAMBERLAIN.

The following paper was read by Prof. W. P. TROWBRIDGE:

ON THE DETERMINATION OF THE HEATING SURFACE REQUIRED IN STEAM PIPES EMPLOYED TO PRODUCE ANY REQUIRED DISCHARGE OF AIR THROUGH VENTILATING CHIMNEYS.

To ventilate a room properly requires the frequent removal of vitiated air and the introduction of fresh or pure air, the quantity, by weight, of the air introduced and rejected being equal in a given time.

If the process be continuous, and the proper amount of air be admitted and removed every hour or minute, the only other requirements are that the entering air shall be pure, that it shall be properly warmed in cold weather, either before it enters the room or by the mixture and diffusion of warm and cold air in the room; and that the introduction and removal of air shall take place by gentle or inappreciable currents in such a manner that the pure air may be thoroughly diffused throughout the room before it is removed.

These simple rules are easily stated and comprehended. It is also well understood that to produce a movement of air requires force in proportion to the mass moved and the velocity imparted to it.

The problems which arise in ventilation consist mainly in determining the position, arrangement and sizes of the passages through which the air enters and leaves, and the proper adaptation of these passages to the forces which produce the movement.

On the correct solution of these problems, too often misapplied or misunderstood, successful ventilation depends.

The various modes of producing the movement of air for ventilation are:

First.—Ventilating chimneys or flues in which the movement is caused by the difference in weight between the heated air in the flue and the cooler air outside. This requires that the air before entering the flue shall be warmed, and the heat necessary may be that due to the heat of the room when fires are necessary for warmth; or the heat may be imparted by stoves in the base of the flues, by gas jets, or by steam-heated pipes.

Second.—The movement may be produced by fans or blowers or by steam jets - the latter being seldom applied.

The object of this paper is to investigate the laws which govern the ventilation when the air is heated at the base of the flues by steam pipes, the air in its passage to the flue receiving heat by its contact with the exterior surface of the pipes. As far as I am informed these laws have not heretofore been developed, and, as this system is a very simple one, capable of very extended applications, it is hoped that the following analysis may at least lead to a full discussion of the subject:

Let it be supposed that the air in a room is to be renewed at the rate of (W) lbs per second. Suppose also that it is to be rejected through a flue whose cross-section in square feet is (A), and height in feet (H). And that it is to be heated by steam coils whose aggregate exterior surface in square feet is (S)

The following notations will be used:

W. Weight of air removed per second (lbs).

H. Height of flue in feet.

S. Exterior surface of steam pipes (sq. feet).

A. Area of cross-section of flue (or flues).

T_a. Absolute temperature of external air (found by adding to the thermometric temp. Fahr. the number 459.4).

T_c. Absolute temperature of air in the flue.

T_s. Absolute temperature of steam in the pipes.

D_a. Weight in lbs. of a cubic foot of the external air.

D_c. Weight in lbs. of a cubic foot of the flue air.

V^1. The theoretical velocity of the air in the flue.

V. The actual velocity.

r. The rate in units of heat per hour, per square foot of the surface (S) (and for each degree difference between T_s and T_a) at which the air receives heat from the pipes.

k A coefficient of loss of velocity such that $kV=V'$.

p The unbalanced pressure (upward) due to the difference of weight between the column of air in the flue and a corresponding column of external air.

Then,

$$p=H.D_a-H\,D_c \text{ or } p=H\,(D_a-D_c) \qquad (1)$$

This pressure may be represented by the weight of a column of flue air of a height—

$$\frac{p}{D_c} = \frac{H\,(D_a-D_c)}{D_c} \quad , \quad . \qquad (2)$$

and the velocity in the flue will be found from the expression

$$\frac{V'^2}{2g} = \frac{H\,(D_a-D_c)}{D_c} \quad . \quad . \qquad (3)$$

or,

$$V' = \sqrt{\frac{2g\,H\,(D_c-D_a}{D_c}} \qquad (4$$

But from the Mariotte-Gay-Lussac law we have—

$$\frac{D_c}{D_a} = \frac{T_a}{T_c} \text{ or } D_c = D_a\,\frac{T_a}{T_c} \qquad (6)$$

substituting this value of D_c in formula (4) there results—

$$V' = \sqrt{2g\,H.\left(\frac{T_c-T_a)}{T_a}\right.} \qquad (7)$$

In this expression the theoretical velocity of flow is expressed in terms of the height of the flue and the absolute temperatures of the flue air and the external air. From formula (7) we have—

$$T_c-T_a = \frac{V'^2}{2g\,H} \times T_a \quad . \qquad (8)$$

The quantity of heat transferred to the air may be represented by

$$\phi = W.\,c.\,(T_c-T_a) \quad . \qquad (9)$$

in which ϕ represents the quantity of heat in units of heat per second, and c the specific heat of air at constant pressure ($c = 0.238$.)

All of the above formulas are well known. The following are believed to be new:

The quantity of heat imparted to the air may also be represented by $\phi' = \frac{S.\,r.\,(T_s - T_a)}{3600}$ in which is the quantity of heat imparted per second, and as from the nature of the problem $\varphi = \phi'$ we have

$$\frac{S.\,r.\,(T_s - T_a)}{3600} = W.\,c.\,(T_c - T_a) \qquad (10)$$

or

$$T_c - T_a = \frac{S.\,r.\,(T_s - T_a)}{W.\,c.\,3600} \quad . \quad . \qquad (11)$$

combining this equation with (8) we have—

$$S'.\,r.\,\frac{(T_s - V_a)}{3600} = \frac{V'2}{2g\,H.} \times T_a \quad . \qquad (12)$$

and

$$S' = \frac{V'^2.\,W.\,c.\,T_a}{2g\,H.\,r.\,\frac{(T_s - T_a)}{3600}} \quad . \quad . \quad . \qquad (13)$$

This expression gives the total heating surface in the pipes in terms of the velocity, the height of the flue, the weight of air discharged per second, and the absolute temperature of the external air.

If we substitute for V′ its value in terms of V, the actual velocity, we have—

$$S' = \frac{K^2\,V^2\,W.\,c.\,T_a}{2g\,H.\,r.\,\frac{(T_s - T_a)}{3600}} \quad . \quad . \quad . \qquad (14)$$

and others

$$W. = D_c\,V.\,A.$$

$$S' = \frac{K^2\,V^3\,D_c\,c.\,A.\,T_a}{2g\,H.\,r.\,\frac{(T_s - T_a)}{3600}} \quad . \quad . \qquad (15)$$

another expression for S'.

These two expressions exhibit the laws of the movement of the air, giving the quantity of heating surface required under any special conditions of area and height of flue, temperature of external air, and velocity of discharge.

The constant (r) may be found approximately from the experiments of Mr. C. B. Richards, made at Colts Arms Co., of Hartford. The constant K depends upon the frictional resistance which the air encounters in its passage into and through the flues. The velocity V may be assumed, and should not be greater than four or five feet per second. The smaller the velocity and the larger the flues, the less will be the required heating surface, and the greater the economy of the apparatus for ventilation.

The following paper was read by Prof. H. L. FAIRCHILD:

ON A PECULIAR COAL-LIKE TRANSFORMATION OF PEAT, RECENTLY DISCOVERED AT SCRANTON, PENN.

The material which we shall notice this evening has naturally been regarded, on account of its associations, as illustrating in some degree the formation of coal. A brief description of that alteration of peat which has resulted in the formation of coal, is therefore desirable.

Peat results from decomposition of vegetable matter under water. The latter excludes the atmosphere and largely prevents the oxidation, which removes the vegetable debris on the upland, and which if rapid we call combustion, or if slow, decay. In northern regions peat-swamp vegetation is commonly a sort of moss (Sphagnum) which grows upward as it dies below. Great peat deposits are also produced in lower latitudes from the debris of forest trees. The great Dismal Swamp is a fine example, and in the Hackensack and Newark meadows we have examples of peat-formations of great depth, produced by the slow subsidence of the region and the accumulation of salt-marsh vegetation.

In former geological ages, immense peat deposits were produced in the vast lowlands along the borders of the continents, or at the deltas of the ancient rivers. These great swamps were frequently submerged in the sea and deeply buried beneath mud and sand. This event occurred perhaps many times in a single locality. The buried peat slowly decomposed. Much of the hydrogen and oxygen of the vegetable tissue, and some of the carbon, were eliminated. The remainder was consolidated by the weight of the superincumbent strata, and the result is bituminous coal. Thus we have the six to twenty coal beds of Pennsylvania, or the one hundred coal-seams of Nova Scotia.

The evidence that our coals are primarily formed in this manner is abundant, clear and incontrovertible. Few subjects are by our inductive science more definitely settled than this. We find these buried vegetable deposits in every stage of decomposition and alteration. Where the containing rocks are undisturbed, lying in their original positions, the coal contains a large proportion of volatile matter, and is bituminous. But where the rocks are dislocated and folded the coal is, by the pressure and heat, changed to anthracite or perhaps to graphite. The proportion of fixed carbon, or the degree of alteration, is always proportionate to the amount of disturbance which the associated rocks have suffered. Hence anthracite coal is a metamorphosed coal, just as marble is metamorphosed limestone, or quartzyte is metamorphosed sandstone. The metamorphism of coal is still going on. The escape of the volatile matter, in which the change consists, is observed in the mines, in the production of the explosive "fire-damp," and the poisonous "choke-damp."

Running from cellulose through wood, peat, and coals up to graphite we have a complete series; the difference being the loss of hydrogen, oxygen and in a less degree of carbon. This table, after LeConte, exhibits the proportions of the elements *by weight*, the carbon being reduced to a fixed quantity:

	Carbon.	Hydrogen.	Oxygen.
Cellulose	100	16.66	133.33
Wood	100	12.18	83.07
Peat	100	9.83	55.67
Lignite	100	8.37	42.42
Bituminous Coal	100	6.12	21.23
Anthracite Coal	100	2.84	1.74
Graphite	100	0.00	0.00

Anthracite coal, it will be seen contains a very small proportion of volatile matter, and graphite none at all. No two specimens of coal from different beds or areas are likely to yield upon analysis exactly the same results. This is due to differences in degree and manner of decomposition, the varying degree of metamorphism, the varying impurities, and perhaps a difference in the kind of vegetation. Anthracite coal naturally contains more ash than bituminous, because it is more concentrated, and of course peat has the least proportion of ash, simply derived from the inorganic matter of the plant.

The substance to be described was found in a peat-bog in the city of Scranton during the past summer. It has received attention from the newspaper and scientific people of the eastern coal region of Pennsylvania; and has been recently mentioned in the *Am. Jour. of Science* for Dec. by a quotation from a letter of a Scranton gentleman to the *Engineering and Mining Journal.*

Scranton lies in the midst of the Lackawanna anthracite coal-basin, which forms the northern half of the Wyoming basin. Since the financial panic of 1872 the city has grown but slowly, and a swamp lying in the midst of the city had remained unoccupied, except as an old dumping-ground for cinders from the furnaces. The city having been lately made the county-seat of the newly created Lackawanna county, this swamp was selected as the site for a court-house. In excavating for the foundations there was found a bed of excellent peat, 10 to 14 feet deep. I visited the excavation and collected specimens from depths of 3, 5, 8, and 13 feet. These specimens, of which a series are before you, were, of course, when fresh and saturated with water several times their present bulk.

The peat from the greatest depth was highly decomposed, or very "ripe." It was fine-grained, close in texture, and although soft held its shape well, cutting like cheese. The color, when freshly cut, was a yellowish-brown, but changed rapidly to a dark-brown, almost black, in a few minutes. Upon drying, the color becomes a lighter or grayish-brown. The rock below the ripe peat is a clayey sand. This is somewhat impervious to water ; but it is likely that beneath it is a more clayey bed which originally held the water and occasioned the swamp.

In the midst of the ripe peat, termed muck in the letter above mentioned, there was found, at various times and at different places, in excavating for the division walls, a substance resembling to the eye a bright coal—anthracite if you please. This did not occur in beds or layers, or in any apparent regular manner, but in irregular scattered or branching masses. You will observe in these dried specimens how intimately the coal-like matter and the ordinary peat are mingled. The two kinds cannot be separated, and it is with difficulty that the dried material can be gotten entirely pure for purposes of analysis. It shrinks upon drying, to a greater degree than the unchanged peat. Masses which I thought would afford fair-sized dry samples have nearly disappeared. The fresh material has been described as a tough jelly, which is perhaps a fair description. It was somewhat elastic, like a mass of soft india-rubber, but would break before bending greatly. I should compare it to a very firm but brittle jelly. The fracture had the lustre of a true coal, and in the dried state the resemblance is perfect. Being found in the midst of an anthracite basin, unscientific people naturally supposed from its associations that whatever bearings it might have upon coal would relate to anthracite coal, not knowing, or not remembering, that anthracite is a metamorphic coal.

Mr. N. L. BRITTON, Geological assistant at the School of Mines, New York, has made approximate analyses of this altered peat, from material which I carefuly selected ; also of the peat contiguous to the transformed matter (within the distance of an inch) ; and of the ripe peat from a depth of 13 feet in another part of the excavation. The analyses are of thoroughly and equally dried samples, and afford the following percentages :

	Moisture at 115° Cent.	Volatile Matter.	Fixed Carbon.	Ash.
1. Ripe Peat....................	6.225	63.875	4.625	25.275
2. Peat adjacent to 3....................	3.775	22.125	4.625	69.475
3. Transformed Peat....................	11.350	52.800	24.725	11.125
4. Transformed Peat....................	66.758	9.826	4.012	19.404

Number 4 is by the Pennsylvania State Chemist, as published in the

American Journal of Science. The moisture is taken at 212° Fahr., and the analysis is evidently of the fresh material.

To obtain a fairer comparison, and if not strictly accurate, yet sufficiently so for our purpose, I have computed the percentages with the moisture eliminated.

	Volatile Matter.	Fixed Carbon.	Ash.
1. Ripe Peat	68.115	4.932	26.953 (White)
2. Adjacent to 3	22.993	4.806	72.201 (White)
3. Transformed Peat	59.560	27.891	12.549 (Pink)
4. " (State Chemist)	29.559	12.069	58.372
Bituminous Coals	30. to 60.	40. to 70.	3 to 6

From this table it will be seen that the composition of the transformed peat, number three, is about that of a very "fat" bituminous coal, that is, one containing a large proportion of volatile combustible matter, such as are desired for making gas. In number four, the volatile matter and the fixed carbon have nearly the same proportion to each other.

The very large amount of ash in these samples is to be expected, on account of the small size of the peat-swamp, which allowed much inorganic matter to be blown or washed in over the whole surface. But the varying amount of ash would indicate that the peculiar physical character of the peat was not due to the *amount* of inorganic matter. The ash of numbers one and two was white, while that of number three was decidedly pink. This color probably indicates iron; which may possibly afford a clue to the cause of the transformation. The presence of considerable iron either inherent in the mass itself, or derived from the surrounding mass by something like concretionary action, would probably hasten the decomposition; bearing upon this point, the large amount of inorganic matter without iron in the peat contiguous to the transformed peat is remarkable. The physical characteristics are undoubtedly due to the finely divided state of the carbon, mingled with the water and volatile matter. But, however produced, we have here something that is apparently coal, in the midst of peat that is not yet coal.

Except as this substance illustrates a degree or phase of peat decomposition, it is not likely to have any bearing on the formation of coal. The decomposition of a buried peat-bed under great pressure probably involves the whole mass at the same time, and does not proceed by the expansion of such centres of decomposition as are here found.

Samples have been placed in the hands of Mr. Spencer B. Newberry, of Cornell University, who is making a full chemical examination.

DISCUSSION.

DR. L. ELSBERG then said that some 20 years ago he was engaged in experiments on the subject of converting peat into coal by a more rapid process than that occuring in nature. He found that moisture, heat and pressure were, as he supposed, the elements which, together with time, na ture had employed; and these three factors could and can be used really to make a very good coal. On some future occasion he would bring specimens of the manufactured coal and of various kinds of coal to the Academy, and give an account of these experiments and the methods. For a long time his experiments were futile, because it was impossible to make a machine of iron or steel strong enough to withstand the pressure which must be applied to the prepared pulp to reduce it to coal. By the action of super-heated steam, peat is converted into a perfectly homogeneous pulp. By passage of this through any of the ordinary compressing machines used for making bricks, etc., blocks or cylinders are obtained of a substance which, so far as its economic uses are concerned, is not inferior to most qualities of bituminous coal, for gas or fuel. Every effort was made to render the bore perfectly smooth and polished in the cylinder from which the peat was finally pressed out, and for this purpose even glass and porcelain were employed. However, the peat was found to be so impalpable that it was forced into the microscopic pores of the metal, and even of porcelain and glass. The peat thus inserted itself in the finest possible particles, which acted like wedges, chipping off small pieces from the interior of the cylinder. No matter how fine and smooth the bore of the cylinder was made, after very beautiful working for a few days, gradually this material would insert itself in the microscopical interstices of the metal, until gradually the working of the machine was stopped or an explosion ensued. A great many trials were made and much money spent, and finally the enterprise was given up.

MR. A. A. JULIEN remarked upon the voluminous literature connected with the study of peat, and the widely varying results, notwithstanding the enormous amount of labor that has been expended. The study of this material has been approached by investigators from two economic points of view; its relations to agriculture, and its employment as fuel. In investigations of the former class the larger number of analyses have been ultimate—*i. e.*, to determine the carbon, oxygen, hydrogen, nitrogen, etc., which make up peat and its allied products. This gives very conflicting results; the slightest possible change in the amount of water, the oxidation or dissociation of the material, even while during analysis, yielding very different results even in the hands of a single investigator. The other method is approximate, simply intended for the estimate of the value of coal or peat as applied to the purposes of fuel, and is that represented in the analysis of Mr. Britton. Such analysis, however, can throw but little light on the origin of the substance ; organic acid seems to be further indicated by the red ash derived from the coal-like substance (Analysis No. 3), the white ash of the enclosing peat showing the residue of silica and alumina insoluble in the humous acids.

Further, the physical characteristics of the substance described by Prof. Fairchild, its brittle jelly-like character while moist, and extreme shrinkage on drying to bright coal-like brittle flakes, are identical with those of apocrenic, humic and other organic acids. These considerations render it highly probable that this substance has been produced within the peat at Scranton merely by the leaching out of the upper portions of the bog and the concentration of soluble salts of organic acids, in part crenates, along certain planes and in small cavities within the denser part of the peat toward the bottom of the bog. There is as yet no evidence, however, that these facts have any important connection with the formation of bituminous coal, much less with that of anthracite, represented by these specimens. A third method of the examination of peat is founded upon the determination of its proximate constituents or compounds, both those of amorphous character and various organic acids. From insufficient knowledge of the exact constitution and nature of these acids, especially in their various hydrated forms, the method is very difficult and has thus far had but limited application. Only such a mode of examination can throw light upon the character of the bright jelly-like substance in the Scranton peat.

Some statements by Prof. Fairchild, however, give a clue to its identity. He has mentioned a rapid change of color in specimens of the peat taken from a depth of thirteen feet, the yellowish-brown color of the surface becoming blackish brown in a few moments while being handled. This seems to indicate not the trifling change produced by drying, but the characteristic reaction of crenic acid, well known to chemists by its immediate oxidation and partial conversion into apocrenic acid. This affects not only the acid but its ordinary salts, *e. g.*, those of iron, and has been observed both in its artificial product in the laboratory, and in nature, in the deposit of iron crenate beneath peat bogs and from the waters of many springs.

Prof. D. S. MARTIN called attention to the resemblance of the lighter colored and solid variety of this peat to the darker variety of the "turba" of Brazil. In the latter he had also observed thin seams of a black bituminous substance looking much like that which occurs in this peat.

The subject was further discussed by Prof. Hubbard and Mr. Parsons.

January 9, 1882.

REGULAR BUSINESS MEETING.

The President, DR. J. S. NEWBERRY, in the Chair.

Number of persons present, 43.

On the recommendation of the Council, the following-named persons, previously nominated, were elected as resident members.

C. H. DENISON,	CHARLES KIRCHHOFF, E. M.
SAMUEL HENSHAW,	EDWARD W. MARTIN,
E. F. HYDE,	W. H. RUDKIN,
VINCENT C. KING,	WALTER LE CONTE STEVENS,

DR. PHILIP VALENTINI.

PROF. J. J. STEVENSON called attention to the announcement of the death of one of the oldest and most eminent fellows of the Academy, Prof. John W. Draper, and after making some remarks thereon, proposed that the society proceed to take some suitable action.

THE PRESIDENT spoke of the eminent fame of Dr. Draper, and suggested that a committee be appointed to prepare a minute expressive of the feelings of the Academy. On motion, it was voted that such a committee be designated by the chair; and Prof. Stevenson and Prof. D. S. Martin were so appointed.

Among the books received, the President called attention to the first number of the "*Bulletin of the American Museum of Natural History*," as marking an important step in the progress of science in New York city. He welcomed the appearance of this publication, which contains novel and valuable matter, with illustrations accompanying descriptions of new species; and earnestly hoped that a large and liberal and worthy policy would enable the Museum to give to the world, in this manner, the benefit of the large stores of scientific material which it has already accumulated, and which will gather more and more around such a centre.

DR. LAURENCE JOHNSON then read a paper of which the following is an abstract.

THE PARALLEL DRIFT-HILLS OF WESTERN NEW YORK.*

(Abstract.)

That section of New York State lying between Lake Ontario on the north, and Cayuga and Seneca lakes on the south, is occupied by a large number of parallel drift-hills, having a general north and south direction. Some of them are two or three miles long, and attain elevations

*This article will probably appear in full in the ANNALS of the Academy.

of 100 or 200 feet above the intervening valleys; but the greater number are shorter and lower. Many of them were, when first cleared of timber, very steep at their north ends, and on their east and west sides; but, with very rare exceptions, the southern slope is gradual.

The large valleys are generally cup-shaped, the lip of the cup being of drift material, as found by many sections observed and cited by the writer. Such valleys were originally occupied by ponds or lakelets, now obliterated by accumulations of muck or peat, though a few (Crusoe lake, Duck lake, etc.,) still remain,

The surface rocks of the region, are, beginning with the lowest, the Medina Sandstone, Clinton Group, Niagara Group, and Salina Group. The Medina occupies the surface for two or three miles south of Ontario, lying at about the level of the lake in the vicinity of Great Sodus and Port Bays; while at Oswego Falls, twenty-four miles east, and at the lower falls of the Genesee, fifty miles west, it rises 100 feet above this level—indicating a shallow valley existing, previous to the ice period, in the region occupied by the parallel hills. The Clinton and Niagara Groups together occupy a tract of four or six or more miles wide throughout the district, the latter forming the watershed between the small streams flowing north directly, or south by a circuitous route to Lake Ontario. From the Niagara Group to Cayuga and Seneca lakes, the surface rock is the Salina, which here attains its greatest breadth in the State. Above and to the south of the Salina, rise in succession the Waterlime, Oriskany, Upper Helderberg and Hamilton, in the latter of which are excavated the basins of Canandaigua, Seneca, Cayuga, Owasco, and Skaneateles lakes. The escarpment of the Upper Helderberg limestones bends several miles to the south when approaching Cayuga and Seneca lakes. This fact, taken in connection with the great depth of these lakes—more than 400 and 600 feet respectively—indicate that in this region was exerted the maximum of glacial force in western New York.

To return to the hills. These are covered to a greater or less extent with bowlders of all sizes, up to three or four feet in diameter, composed of Medina, crystalline, Hudson River, Niagara and Clinton rocks —their relative proportions being in about the order named. Their abundance diminishes from the Niagara outcrop southward. The surface soil, a sandy loam, shades downward into a non-bedded, tough clay, generally red, filled with small, sub-angular, glaciated pebbles and bowlders—in short, a typical bowlder clay, or till.

The opinion held by the state geologists, forty years ago, that these hills were formed by streams of water, is evidently erroneous, since there are no accumulations of river gravel in the valleys, such as must have remained had a broad sheet of drift suffered aqueous erosion. Moreover, the valleys are cup-shaped, even the large river valley exhibiting this feature at a number of points cited by the writer.

Nothing but glacial action is competent to explain the peculiar shape and positions of these hills and valleys ; and the glacier which deposited them must have moved in a general north and south direction, bearing, however, eastwardly to the east of Cayuga Lake, and westwardly west of Seneca Lake. The long axes of all the smaller lakes in this region prolonged, converge toward a point on the present Canadian shore of Ontario. This fact would seem to indicate conclusively that the glacier radiated in cutting through, or passing over, the mountain ridge, exerting, as has been said above, its maximum of force about Cayuga and Seneca lakes. The amount of erosion indicates that the glacier occupied this region for an immensely long period; and the writer thinks he is supported by the evidence in believing it one of the first to come and last to go of all the ice-streams which swept over New York State. The evidence is, moreover, conclusive that the direction of the glacial current in this locality was not south-westerly, as generally maintained by geologists. It may have been a mere deflection of the great south-westerly current, but if so the deflection was permanent. Its great depth—about 2,000 feet from the bottom of Seneca Lake to the top of the highlands on either side, to say nothing of the mass upon their summits—must have greatly influenced its retrograde movement ; and it is therefore possible that it may have blocked the entrance to the St. Lawrence and thus have held back the waters which formed some of the ancient lake regions. The last of these ridges is 200 feet above the present level of the lake, and terminates in the vicinity of Great Sodus Bay. East of this point, the valleys were too deep to admit of a continuous beach being formed ; hence all the higher hills were islands, and the waters circulated freely through the valleys, depositing brick-clays in many of them. [A line of elevations was given illustrating these points.] There are, however, no fossils in these clays, showing that the water was very cold and not far distant from ice—doubtless the foot of the retreating glacier.

The writer quoted from Hitchcock (*Pop. Science Monthly*, Dec. 1881,) and Newberry (Geological Survey of Ohio, Vol. II.) in reference to the motion of the ice, etc., in the lake region ; and from Geikie (" The Great Ice Age"), in explanation of the causes operating to produce the peculiar arrangement of the hills. The latter author describes such hills as occurring in broad valleys in Scotland, and believes that they are formed underneath the glaciers by alternations of lateral pressure. In the region under consideration there was a broad shallow valley, as shown by the depression in the Medina sandstone, and there must have been great and striking alternations of pressure, at least toward the close of the period of advancement of the ice, due to the stream being forced into the deep and narrow valleys of Seneca and Cayuga—alternations of pressure which must have been felt throughout the mass for some distance northward.

DISCUSSION.

Dr. NEWBERRY expressed his opinion of the great value and importance of the observations thus given, in a region that has been much discussed and yet but little understood.

Prof. D. S. MARTIN inquired whether the direction and position of Oneida Lake would not bring it into the series of radiating lake-basins mentioned by Dr. Johnson, as the most easterly member thereof.

Dr. JOHNSON replied that while its general course would correspond with such a view, yet that the basin of Oneida Lake is so different, in its shallow character, from the others to which he had referred, that he regarded it as not related to them geologically.

Dr. J. S. NEWBERRY then read the following paper:

HYPOTHETICAL HIGH TIDES, AS AGENTS OF GEOLOGICAL CHANGE.

Prof. Robert Ball, of Dublin, has recently delivered a novel and interesting lecture, with the poetical title "A Glimpse through the Corridors of Time," in which he advances a theory in regard to the agency of the tides in producing changes on the earth's surface, which is so discordant with the facts observed and the conclusions adopted by geologists, that it would seem to call for some notice from them.

In this lecture, the views of Mr. George Darwin, in regard to the history of our telluric system, are accepted, and it is claimed that the moon was at one time a part of the earth, but that while the latter was imperfectly consolidated, it was thrown off by the preponderance of the centrifugal over the centripetal force. After the separation, according to Prof. Ball, the earth and moon revolved simultaneously around a common axis once in three hours. Since that time, the moon has been gradually receding, and lagging behind in its rotation, until it is now 240,000 miles away, and revolves but once while the earth makes twenty-seven revolutions of twenty-four hours each.

The special purpose of the lecture was the announcement of the discovery of a new agency in geological change, and one represented to be of transcendent power, viz., ancient high tides. At the present time, with the moon 240,000 miles distant, its attraction produces a tide reaching sometimes, as in the Bay of Fundy, a height of sixty feet, a tide which, in its ebb and flow, causes a considerable amount of change in the land, washing away banks and cliffs, and transporting to sea great quantities of detrital matter.

Prof. Ball asserts that at certain times in the recession of the moon from the earth, and after the cooling of the globe had produced the precipitation and accumulation of ocean waters, the attraction of the moon acting inversely as the cube of the distance, produced tides of stupendous altitude as compared with any now witnessed. For example, supposing the earth to have been largely covered with water, when the moon was 40,000 miles away, one sixth of its present distance, its attraction must have been thirty-six times as great as at present, and its efficiency as a tide-producer two hundred and sixteen times as great as at present. This would give, for an average tide corresponding to a tide of three feet now, a height of 648 feet.

Prof. Ball pictures to his audience the effect of a tidal wave of this height rushing over and retreating from all shores twice in each short day, and justly ascribes enormous destructive power to such an agent. This condition of things he fancies to have existed forty or fifty millions of years ago, perhaps when the first sedimentary rocks now known, the old Palæozoic and Archæan strata, were deposited ; and since in certain localities there were accumulations of mechanical sediments, shales, sandstones, etc., to the depth of several miles in these ages, they are explained to be the result of the action of these tremendous tides.

Prof. Ball further ascribes to this agent the greater part of the changes that have taken place on the earth's surface, and claims to have revealed to geologists in this discovery the most important factor in all their data for writing the ancient history of the globe, and one of which they seem to have been strangely ignorant.

Now, all this is exceedingly interesting, and important, *if true*; but in behalf of the geologists, I venture to report certain facts which seem to be quite irreconcilable with it. There can be no question that a tide of 600 to 1000 feet in height, sweeping over all shores and lowlands twice a day, would be a most powerful destructive and creative engine ; and it may be conceded at once that its potency in remodeling the earth's surface would far surpass any agent of change now in action.

Let us imagine for a moment what the effect of a tide two hundred times greater than the present would be, if called into existence on the Atlantic coast of America to-day. The height of the tide along our coast varies from nine to twelve feet, and we may say the average is ten. This would give a height of two thousand feet to the tide produced by the moon if only 40,000 miles distant. The effect of such a flood would be so tremendous that it can hardly be realized. The whole littoral plain, two hundred miles wide, which forms the topographical margin of the continent, now half sub-marine, half sub-aerial, would be swept twice a day with a wave not less than a thousand feet in height ; and a bore fifty times as high as that of the Hoogly would rush up the

Hudson and Mohawk, and sweep the valley of the Mississippi to the basin of the Great Lakes. Rocks would be torn from their beds, and with all loose material, boulders, gravel, sand and clay, would be swept to and fro with overwhelming violence, and finally be spread far out over the bottom of the adjacent ocean. All this broad littoral zone, now crowded with life, and the scene of greater vital activity than any other equal area above or below the ocean level, would become at once a howling wilderness, where nature's forces waged perpetual war, and life would be impossible.

So on all other shores, the physical and vital changes would be immeasurable. Erosion would be carried on with such energy that soon all continents would be worn away, all mountains be transported into the sea. All coral reefs, all sea-weeds, and indeed nine-tenths of all the life on the globe, would, however, be swept out of existence before that time. Half the land of the globe would be submerged and desolated, and, with the destruction of the marine and the restriction to narrow limits of terrestrial vegetation, the pabulum of animal life would be so much reduced that the globe would be practically depopulated.

It may also be said that if, as we suppose, the precipitation of ocean waters took place before the corrugations of the ear h's surface had assumed any considerable magnitude, and it was nearly or quite covered with water, tidal waves 500 feet or more in height, sweeping over the globe in rapid succession, would have worn away the emerging land as fast as it appeared, would have prevented the formation of continents and have precluded the existence of land animals or plants.

From these facts, it will be seen that if such tides had been at any time in existence on the earth's surface, traces of their action would be universal and indisputable.

Having studied with some care the geological record in places where it is as nearly complete as anywhere, I must say that I not only fail to find any proof of the existence of these stupendous tides pictured to the imagination by Prof. Ball, but, on the contrary, the whole of that record, from the Archæan to the Tertiary, offers abundant and conclusive evidence against such a theory.

As to what took place before the deposition of the Laurentian strata, we can have no knowledge, because they are the oldest known rocks yet the era of their deposition can hardly have been less than twenty or thirty millions of years ago. Though much changed from their original condition as aqueous sediments, we are yet able to recognize in them the prototypes of the sandstones, shales and limestones of later formations, and we may fairly conclude that they were deposited under like conditions. In the gneiss and granite of the Laurentian we have representatives of the coarser sediments formed along shores; the slates are the clays of ancient times, the deposits of quiet waters off-shore; while the marbles, which in some places form a considerable portion of the Laurentian series, are undoubtedly organic sediments that accumulated in relatively deep and quiet water by the slow process of growth and decay of animal structures. Thus the slates and the limestones are records of long continuance of quiet times and the absence of great high tides. Even the gneisses and granites are strata which must have been very different from such as would be formed by the impetuous rush to and fro, over the ocean's shores, of a semi-diurnal wave hundreds of feet in height.

The Huronian series, which follows the Laurentian, consists mainly of slates, sometimes beautifully ripple-marked, and of beds of iron ore —all shore and shallow-water deposits, but speaking of quiet times and no high tides.

The Cambrian rocks are but imperfectly shown on this continent, but they are all fine mechanical sediments, or earthy limestones, often fossiliferous, deposited along the Laurentian shore, but with an absence of all coarse material and cross-bedding, such as would be produced by rapid currents or violent ebbs and flows.

In the Silurian series, which is here remarkably complete, we have a record that tells with great clearness the physical, as well as the vital, history of the continent at that age. The Potsdam sandstone is an old beach spread over large areas of pre-existent land by a slow and quiet subsidence and an invasion of the Lower Silurian sea. The Laurentian highlands, the Adirondacks, etc., formed the shores of that sea, and the Silurian rocks were deposited in it. We know with considerable accuracy the boundaries of this sea, and can trace its shore line for a thousand miles as easily as we can that of the present Atlantic coast, and can study the littoral phenomena as satisfactorily. On the old beach, as on the new, gentle zephyrs covered the shelving bottom with ripple-marks; the stems and fronds of sea-weeds are in places thickly interlaced, the beach-loving brachiopods strewed the shore with their whole or broken shells, and the boring annelids pierced the sand with innumerable holes. This automatic and indisputable record is so clear and simple that a child may read it, and it tells in unmistakable language that in the beginning of the Lower Silurian age the littoral conditions were essentially the same as now, and that no high tides such as we have been considering could possibly have swept these shores.

Above the Potsdam sandstone is spread a sheet of organic sediments —the great Trenton limestone group—in places a thousand feet thick, composed almost entirely of the hard parts of animals which inhabited the sea. These accumulated slowly age after age, in water so quiet that the most delicate marine organisms are beautifully preserved. In places the Trenton limestones abut directly against the Laurentian cliffs which formed the shore, and which suffered so little wear that they contributed scarcely anything to the organic sediment deposited at their base. This record hardly requires translation to be understood by all, and its antagonism to the proposed theory is apparent and irreconcilable.

Toward the close of the Lower Silurian age, the sea slowly retreated from the land it had before invaded, forming wide areas of shallow water in which grew countless numbers of sea-weeds and delicate graptolites, the carbonaceous matter of which, mingling with a fine wash from the land, produced the bituminous clays which we now call the Utica slate. It is evident that the organisms which supplied the combustible matter of this deposit could only have lived in quiet lagoon-like bays, and their presence and product, with the fineness of the inorganic sediment, are incompatible with Prof. Ball's theory.

Similar phenomena teach the same lesson in the records of the Devonian, Carboniferous, and later geological ages. In the Devonian rocks we have another and apparently conclusive argument against extraordinarily high tides, for here are coral reefs, rivaling in extent those of the tropics at the present day. Now unless the reef-building polyps were formerly altogether different in habit from those now living, these coral reefs must have been formed in water not exceeding two hundred feet of average depth and not subject to great oscillations of level. High tides would now effect the rapid destruction of the whole race of reef-building animals; at the ebb exposing them to the air and sun for hours, and at the flood burying them too deeply for their continued existence.

The abundant sea-weeds buried in the rocks of the Palæozoic and later ages, offer an equally strong argument against the high-tide theory. Nearly all the sea-weeds now living in our oceans occupy the immediate shore, and chiefly grow within a depth of from 50 to 100 feet from high-water mark. It is easy to see that if the present oceans were affected by a movement like that described by Prof. Ball, the zone the sea-weeds occupy would be the scene of the greatest mechanical violence, and they would be alternately left to dry in the sun, or be torn with resistless force from their anchorage and scattered over the land washed by the flood tide. On every old beach, however, of which we find so many in the geological series, the casts of the fronds and stems of sea-weeds are as plainly discernible as on our present shores.

In view of these facts, and others of similar import which might be cited, we are compelled to reject this theory of high tides, at least for the interval which separates us from the beginning of the Laurentian age; in other words for the entire reach of geological history; and we are compelled to infer that either the astronomers are mistaken in their views of the genesis of the moon, and that she never formed part of the earth's mass, or that her separation and recession to near her present distance took place before the beginning of geological history. Certainly so much of the geological record as is now submitted to our inspection, offers no evidence in confirmation of, but much that is diametrically opposed to, this high-tide speculation.

COLUMBIA COLLEGE, NEW YORK, *January 2nd*, 1882.

MR. WM. EARL HIDDEN exhibited a remarkable and perhaps unique stone implement from North Carolina. Its form is that of a parallelogram of nearly a foot in length, and five inches in breadth. The lower face is slightly convex from end to end, and its upper face rises into a conical or pestle-shaped handle, some six inches high, at about the center. Dr. Newberry had suggested that its probable use was as a corn-muller. The specimen was plowed up in a field near Waynesville, Haywood Co., N. C., some three years ago, and has been in Mr. Hidden's cabinet for over a year. The material is a very compact gneiss.

THE PRESIDENT remarked further on this very singular implement, and repeated his belief that it was probably used to grind corn, upon a flat or concave stone, making comparison of it with other forms of mullers, etc., known to us from various parts of America.

He also laid before the Academy some of the advance plates of the Palæontology of New York, prepared for the forthcoming volume by Professor Hall, and spoke of the great importance of a proper appropriation by the Legislature for the completion of this noble monument to American science. There was danger that much of this carefully prepared material might fail of publication, and be lost to science, by a mistaken and unworthy policy of "economy," and he suggested that the Academy might, with great propriety, memorialize the Legislature on this subject.

Other remarks were made, in the same spirit; and it was voted that the President and Secretary be constituted a committee to express the views of the Academy in the direction indicated.

January 16th, 1882.

SECTION OF PHYSICS AND ASTRONOMY.

The President, Dr. NEWBERRY, in the Chair.

Twenty-seven persons present.

Prof. JOHN K. REES read the following paper:

THE INTERNATIONAL TIME-SYSTEM.

For the past thirty years, observatories situated in different parts of the world have undertaken to "give time" to their adjoining sections of country, by the use of the electric telegraph.[1]

At this present moment, prominent places in England and Scotland receive their time-signals from the Royal Observatory at Greenwich. There is but one standard time for the island, viz., the Greenwich time —Ireland probably gets her time from the Observatory at Dublin.

In Paris the Observatory clock controls by electricity many secondary clocks of fine workmanship distributed throughout the city.

There is also in Paris another system for distributing time, viz., the Pneumatic system. Dials in private houses, on the streets, etc., are connected by pipes with a central reservoir containing air. From this reservoir, by proper mechanism, is sent every minute an impulse, which, compressing the air in the pipes, moves the minute-hand of each dial forward one minute-space. The system has met with great popular success on account of its cheapness. It is to be said, however, that the time required for the impulse to travel from the reservoir to any dial is appreciable, and varies with the distance of the dial from the central reservoir. Some of the dials are therefore ten to twenty seconds slower than dials near the impulse-generator.[2] From many other observatories in Europe radiate time-systems of greater or less extent.

In our own country, the observatories at Washington, Cincinnati, Cambridge, Albany and New York, began about twenty-five years ago to furnish time to railroads, jewelers and government offices. The demand for accurate time has increased each year, until now we find many widely extended systems. The most important of these time-distributing centres are as follows:

1. The Naval Observatory System of Washington, D. C. This system drops a noon-time ball in Washington, furnishes time to the government and city offices, and to the railroads. The Observatory clock can be connected with the wires of the Western Union Company, so that time-signals can be sent to any part of the United States.[3]

2. The Harvard Observatory System, Cambridge, Mass. This supplies time to many business houses in Boston, drops a noon-time ball from the roof of the Equitable Life Insurance Company's building, and furnishes all the railroads entering Boston, and other roads, with clock signals.[4]

3. From Allegheny, Pa., Professor Langley sends time to Pittsburg, and also to the Pennsylvania Railroad.[5]

4. The Dudley Observatory at Albany furnishes time to Albany, and to the New York Central Railroad.[6]

5. The Observatory at Mount Lookout, near Cincinnati, supplies the city with time-signals, and several railroads get their time from the same observatory.[7]

6. The New York City system is under the control of the Western Union Telegraph Company. A noon-time ball is dropped from a pole on the roof of the company's building, and clock signals are sent to many subscribers in the city. The central clock here is regulated by time-signals received from the Naval Observatory at Washington, from Professor Langley's observatory at Allegheny, Pa., and from Harvard Observatory.

7. The Winchester Observatory (Yale College) system distributes time to the railroads and to several cities in the State of Connecticut. The State "has enacted a statute making the use of New York time compulsory upon all transportation companies within her limits."[8]

8. The Dearborn Observatory, of Chicago, is the centre of that city's time-system, and supplies several railroads with time-signals.

9. Radiating from the Observatory of Washington University, St. Louis, there is a city time-service of considerable extent.[9] Arrangements have been made to send time-signals over the railroad lines centering at St. Louis, South as far as Texas, and West probably as far as Denver.

10. The Morrison Observatory, at Glasgow, Missouri, using Western Union wires, now drops noon-time balls, at St. Louis and at Kansas City, and sends time-signals along several railroads.

These are the most prominent time-centres in the United States. But there are many other centres of less importance. From almost every public and private observatory time is sent, in one way or another, for the regulation of neighboring clocks.

Every year the demand for accurate time becomes stronger and more extended. The supply is fully equal to the demand. It is possible for any business concern or private individual to obtain accurate time from some observatory near by at very small expense and trouble.

The instant of mean or clock noon, at any place, is the time when the mean sun is on the meridian of the place. It is noon then for all places on that meridian. In four and a half seconds (for lat. 40°40) it is noon for places on the meridian about one mile west of the first meridian. Places about fourteen miles west of the first meridian will have local noon one minute later, and so on.

No two places can have, astronomically speaking, the same local times unless they are on the same meridian.

In large cities, and over lines of railroads, it has long been the custom to disregard the changes in the local times as we pass to the east and to the west; and the time, say, of the City Hall is used as the standard time for the whole city; and the time of some city on its line is employed as the standard time for railroads. The time adopted by a railroad soon becomes the standard for all cities along its line, and, shortly, local time, in its astronomical or true sense, is disregarded.

Prof. Cleveland Abbe has shown, in his report to the Metrological Society, that there are now used in this country, in operating railroads, seventy-five different standards of time. "Some of these are in error about a minute or more. Many do not differ among themselves more than one or two minutes. Some of them are furnished with uniform high accuracy by established observatories, others are furnished by jewelers employed by the railroads, and many are of very doubtful reliability."[10]

The scientific men of the country have long felt that there are too many standards, and that there is no system used in adopting them.

The subject of the "Simplification of Time Standards" was taken up in 1875 by a Committee of the American Metrological Society.

This Committee, adopting a system of Prof. Benj. Pierce, recommended (in 1879): *First.*—That the number of standards of time be diminished, and *second*, that there be no more than one standard for every hour of longitude west of the meridian of Greenwich.

The relations of the proposed standard meridians, to Greenwich (in longitude and time), to true local times of places adopting the standards, and the designation of the proposed standard times, are given in the following table:

Geographical Section.	Standard Meridian west of Greenwich	Standard Time slower than Greenwich	Standard Time slower or faster than true "local times."	Designation of proposed Standard Time.
		H. M. S.	Min.	
Newfoundland, New Brunswick, Nova Scotia,	60°	4. 0. 0.	29 slower than St. Johns, N. F.	East'rn Time
			24 faster than St. John, N. B.	
			14 faster than Halifax, N. S.	
Canada, Maine to Florida, Ohio to Alabama, Lower Lakes,	75°	5. 0. 0.	15 slower than Quebec.	Atlantic Time
			18 faster than Toronto.	
			16 slower than Boston.	
			3 slower than New York.	
			8 faster than Washington.	
			19 faster than Charleston.	
			45 faster than Montgomery.	
			14 faster than Buffalo.	
			30 faster than Detroit.	
			38 faster than Cincinnati.	
Miss. Valley, Missouri Valley, Upper Lakes, Texas,	90°	6. 0. 0.	0 faster than New Orleans.	Valley Time.
			1 faster than St. Louis.	
			12 faster than St. Paul.	
			18 faster than Kansas City.	
			19 faster than Galveston.	
			10 slower than Chicago.	
Rocky Mt. Region.	105°	7. 0. 0.	0 faster than Denver.	Mount'n time
			28 faster than Salt Lake City.	
Pacific States, British Columbia,	120°	8. 0. 0	12 slower than San Diego.	Pacific Time
			10 faster than San Francisco.	
			11 faster than Olympia.	
			12 faster than Victoria.	

The section of country situated $7\frac{1}{2}$ degrees on either side of a standard meridian would adopt the time of that meridian. The greatest difference necessary between the *true* local time of a place and the standard meridian would be thirty minutes. These sections of country in this latitude would be about 790 miles wide; at the equator about 1,040 miles wide. As we pass from section to section the time would change by whole hours, the the minute and second remaining the same over the whole country.

As a step in advance, it has been proposed that the railroad and telegraph companies adopt the 90° or 6-hour meridian from Greenwich, (running down the Mississippi Valley and passing through New Orleans) as their standard meridian for the whole country. This time it was proposed to call "Railroad and Telegraph Time."

n the same way it has been proposed to use the meridian through Washington. The meridian through New Orleans being more nearly a central bisecting line for the United States, and being exactly 6 hours from Greenwich, would appear to be the one best suited to the object in view.

Some parties have gone so far as to urge the adoption of one line meridian by the people generally. I can see no objection to the railroad and telegraph companies using the 6-hour meridian, provided the relation of the "R. & T." time to the adopted local time at any place is thoroughly understood. It is, however, too early to urge the acceptance of one meridian on the whole people. If we should adopt the 6-hour meridian as the standard for all local times, business and social engagements would begin at widely different times in different sections of the country. Banks would open in New York City, Boston, etc., at 9 o'clock, theatres would begin their performance at 7 P. M. In St. Louis, Chicago, etc., these same openings would occur at 10 A. M. and 8 P. M. In San Francisco the time would be 12 o'clock for bank, and 10 o'clock for theatre openings; and in like manner for other business and social engagements.

But all the systems so far spoken of are but steps toward the adoption of a uniform standard for the whole earth.

This international system was proposed independently by Hon. Sandford Fleming, Chancellor of Queen's University at Toronto, and by Prof. Cleveland Abbe of the U. S. Signal Service.

The proposed system is plainly outlined in the following

PREAMBLE AND RESOLUTION submitted to the Association for the Reform and Codification of the Law of Nations, at their meeting in August, 1881, at Cologne, in Rhine-Prussia, by President F. A. P. Barnard of Columbia College.

Whereas, Since the creation of a vast system of artificial lines of rapid transit and telegraphic communication, extending through wide differences of longitude upon both continents, great confusion in time reckoning has arisen in consequence of the use, throughout the same districts of country, of the differing times of many local meridians; and,

Whereas, The actual time in use at any place is generally arbitrary and at variance, often by many minutes, with the true local time of such place; and,

Whereas, Such differences between true and arbitrary time are in no way practically disadvantageous in the affairs of life, when universally understood and observed; and,

Whereas, It is practicable, by referring the times of all places on the globe to a limited number of meridians suitably chosen, to create a time-system for the world, so nearly uniform that the minute and the second shall everywhere the same, and the times of places widely differing in longitude shall differ only by entire hours—a system of great simplicity and likely to be conducive to the convenience of all mankind; therefore,

Resolved, That this Association approves and recommends to the favorable consideration of the governments of all nations, as well as to all scientific associations, chambers of commerce, boards of trade, and telegraphic and transportation companies, a time-system for the world, founded on the following principles:

1. Twenty-four standard meridians to be fixed upon, distant from each other fifteen degrees, or one hour each, in longitude, to which, and to which only, the arbitrary local times kept at all places on the earth's surface shall be referred.

2. The prime meridian, or that by reference to which the positions of all the remaining one-hour meridians are to be determined, to be the meridian situated in longitude one hundred and eighty degrees, or twelve hours, distant from the meridian of Greenwich, which prime meridian passes near Behring's Strait and lies almost wholly on the ocean.

3. The diurnal change of count in the monthly calendar to begin when it is midnight on this prime meridian, and the same change to take place for the several meridians successively, until the circuit of the globe has been completed from east to west.

4. The hour of the day at any place to be regulated by the standard meridian nearest such place in longitude, it being reckoned as twelve o'clock, noon, at the moment the mean sun passes such standard meridian. The minute and second to be the same at all times and for all places throughout the earth.

5. The hours of the day to be numbered from one to twenty-four without interruption, and the division of the day into two halves of twelve hours each to be abandoned.

6. For special purposes, as with a view to promote exactness in chronology and to facilitate synchronous observations in science, the day and the time of the day as determined by the prime meridian to be employed as a kind of universal time-reckoning, under the name of COSMOPOLITAN TIME.

7. For the sake of distinction, the hours of Cosmopolitan Time to be denoted by symbols and not by numbers; and preferably by the letters of the English alphabet taken in their order, which, omitting J and V, are twenty-four in number—these letters being also associated with the standard meridians in regular order from east to west, so that F corresponds to the 90° meridian passing near Calcutta, M to the Greenwich meridian of 180°, S to the meridian of New Orleans, 270°, and Z to the prime or zero meridian.

In proposing these resolutions, President Barnard made the following remarks:

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"The bounding lines between the successive meridians at which the count of the hour shall change, it is not proposed to define with the same geometrical precision which characterizes the meridians themselves. The idea is rather to follow any well-known natural or political divisions which fall approximately midway between the meridians, and which will serve as easily remembered reference boundaries. On the American Continent, such lines of demarcation are easily found. The States and provinces which touch the Mississippi river will use valley time; the Canadas, and the States of the Union which lie east of these valley States, and most of which touch the Atlantic, will use Atlantic time; the British provinces farther eastward will use eastern time; the States and provinces which touch the Pacific, will use Pacific time; and all those which lie between the Pacific States and the valley States will use mountain time.

The means by which we expect to establish this system on the American Continent, are partly the voluntary action of the transportation companies; partly the co-operation of municipal corporations and chambers of commerce; and partly local legislation. Already many local organizations have taken steps for the establishment of time-balls and other time-signals in furtherance of the practical introduction of the system. The State of Connecticut has enacted a statute making the use of New York time compulsory upon all transportation companies within her limits. * * * * *

The Governor-General of Canada, the Marquis of Lorne, has been pleased to interest himself actively in promoting the success of the movement. The papers relating to it which have been published by the two associations whose titles have just been mentioned[12], have been forwarded by Lord Lorne, through the British Foreign Office in London, to countries with which Great Britain is in diplomatic relations, and to their scientific associations; and from the Imperial Academy of Sciences at St. Petersburg have been received copies of a report from a committee, of which the eminent astronomer Otto Struve was chairman, cordially approving the project; which report was adopted by the Academy.

Two or three minor features of the scheme contained in the resolutions proposed remain to be mentioned. The first of these is the proposition to abolish the present division of the day into two equal portions of twelve hours each, and to employ instead a continuous count running from one to twenty-four hours in each day. The division at present in use is not a natural one. It is founded, presumably, upon the custom of astronomers to begin the day at the meridian passage of the sun, or the habit of the people to fix the moment of apparent noon by observing the coincidence of the shadow of a vertical style with a line drawn north and south. The natural division of the day is into a light portion and a dark portion. These portions are always and everywhere unequal, except for a single day in the year, or for a single great circle of the earth—the equator. No exact system for the uniform division of time can therefore be founded upon them. On the other hand, no disadvantage can arise from regarding the day as a unit, subdivided into twenty-four equal fractions, a mode of division once very general, at least in Italy, and hardly yet entirely abandoned; while there are very appreciable disadvantages attending the present division into twelve-hour moieties. The first of these is the necessity of using always in speech the word *forenoon* or *afternoon*, in order to identify the portion of the day to which any hour which happens to be mentioned or is to be referred; or, in writing, to place after the number of the hour the explanatory suffix A. M. or P. M. Another and even greater is the uncertainty in railway time-tables as to whether a particular hour is an hour of the night or of the day. The compact form of these tables renders it impossible always to introduce the necessary specifications in their columns, and the inquirer is thus often left at a loss. Some of the tables, in order to remove the embarrassment, have employed the expedient of printing the hours of the night in white letters upon a black ground, while those of the day are printed in the usual way with black letters upon a white ground[13]; but the very adoption of this expedient is a confession of the existence of an evil which we may easily perceive to be quite unnecessary. Let the hours of the day be only continuously numbered from beginning to end, and there will never be any uncertainty as to which part of the day is meant.

Another of the secondary features of the scheme is the designation of a zero meridian. The zero meridian is that from which terrestrial longitudes begin to be reckoned, and that at which, at the close of the day, the count of the day in the monthly calendar shall be momentarily the same for the entire globe. Any meridian which might be chosen, and which should be generally accepted, would answer for this purpose; but such a selection ought not to be made through mere idle caprice. Regard should be had to usages actually existing; and if there is any meridian which has already become more familiar than any other to the great majority of mankind, that circumstance should be counted in its favor. In a contribution made by me some ten years ago to a provisional code of international law drawn up under authority of a resolution of this Association, by the Hon. David Dudley Field, afterwards President of the Association, I endeavored to assign some reasons why the meridian of Greenwich is entitled to be regarded as rightfully the first meridian for purposes of longitude. But the same reasons apply with equal force to the inferior meridian of Greenwich--that is to say, to the meridian twelve hours distant in time, and 180 degrees distant in longitude from Greenwich itself; and as I have found, in consultation wirh others, that there might be danger of awakening national susceptibilites by insisting on Greenwich (though, for myself, I fail to find this consideration serious), I have yielded my first opinion, and propose to fix the first meridian for time and for terrestial longitude at the 180th degree from Greenwich, so that this first meridian will fall almost entirely upon the ocean. As in the monthly calendar the change of count must begin at some particular meridian, it is desirable that this change shall take place, if possible, beyond the limits of all habitable lands; and this is true of the meridian proposed, since, except a small portion of wild and desolate sub-arctic Kamschatka, it scarcely touches any portion of the earth's surface uncovered by water. At this assumed first meridian, therefore, the day in ordinary chronology will begin when the mean sun is on the meridian of Greenwich; so that in fact it will be identical with the astronomical day as reckoned at that observatory.

The last of the secondary features of the scheme which I have to notice, is the proposition to establish, for purposes of pure chronology, and for the facilitation of synchronous observations in science, a special time-reckoning under the name of *cosmopolitan time*. So long as the dimensions of the known world were limited in longitude between the Indies on the east and the Canary Islands on the west, there was no danger of a confusion of chronology to arise from a mistake of an entire day in a date. But at the present time, and since civilization has encircled the entire globe, it is a fact that there are certain hours in every twenty-four, during which, for one entire half of the habitable world the date is a unit more advanced in the monthly calendar than in the other. The change of count must have a beginning somewhere. In the absence of any distinct convention on the subject, it is generally understood that this change begins somewhere in the Pacific Ocean. It happens, therefore, that at the moment when the sun is on the meridian opposed to that of Greenwich, the date for all Asia and all Continental Europe may be, for example, the first of January before noon, while for the entire American Continent it is still the thirty-first of December. On the other hand, when, twelve hours later, the sun is on Greenwich meridian, the date will be the first of January for all the world, but will be afternoon for Asia and Europe and forenoon for America. At present the change of count, as above observed, is supposed to begin in the Pacific Ocean, But if we are to be exact, it ought to begin at some certainly defined meridian; and the present proposition is to make it begin at the meridian distant twelve hours from Greenwich.

The time determined by the proposed zero meridian is, according to a suggestion of Mr. Fleming adopted in the resolution, to be distinguished as cosmopolitan time, and might equally be called universal or absolute time. Any observation made in cosmopolitan time will be fixed with absolute certainty both in the chronological sequence and in the hours of the day, and it can easily be converted, by the addition or subtraction of an even number of hours, into the particular time of each standard meridian. Mr. Fleming proposes, also, that the hours of this universal time shall be distinguished by symbols or letters rather than by numbers. The value of this suggestion consists in the fact that by means of it the danger will be averted of ever confounding cosmopolitan time with that of any other except the prime meridian." [14]

Delegates from the American Metrological Society and from the Canadian Institute, were sent to the International Geographical Congress held at Venice in September, 1881. These delegates laid before that Congress the above proposed International time-system. Group 1, to which the resolutions were referred, reported as follows: "The Group 1 considers and emits the vote that within a year an International Commission should be appointed by the Governments to consider the question of an Initial Meridian, having in view not only the question of longitude, but especially that of hours and dates. The Commission should be composed of scientific men such as geodesists, geographers, and men who represent the interests of commerce, etc. Three members should be named by each nation. The President of the Italian Geographical Society is requested to take the initiative in bringing the subject before his Government and foreign geographical societies, and to take the necessary steps for the realization of the request contained in the resolutions. The Group desires to draw attention to the proposition of the American delegates that the proposed International Commission should meet at Washington on or before May 1, 1883."[15]

From what has been shown, it appears that the proposed system is being widely discussed, and is generally favorably received. Efforts have been made to bring the whole subject before the railroad men of the country. Communications were presented at the General Time Convention of all the roads in the United States, held in New York City in October, 1881, from Professor Abbe, chairman of the committee on Standard Time of the American Metrological Society, and from Professor Ormond Stone, chairman of the committee appointed by the American Association for the Advancement of Science. These communications were referred to the secretary, with directions to report at the meeting to be held in Cleveland, in April, 1882. Public opinion is being informed in regard to the proposed system. In the near future we may hope to see the adoption of the suggested standards.

Prof. D. S. MARTIN read by title the following paper, to appear in full in the forthcoming Annals of the Academy, Vol. II, Nos. 7 and 8:

DESCRIPTIONS OF NEW SPECIES OF FOSSILS FROM OHIO, WITH NOTES UPON SOME OF THE FORMATIONS IN WHICH THEY OCCUR. By Prof. R. P. WHITFIELD.

He also presented the full programme of the Academy's Lecture-course for the season, in behalf of the Committee on Lectures. The course comprises the following subjects:

January 23.—THE MORAL BEARING OF RECENT PHYSICAL THEORIES. Prof. BENJAMIN N. MARTIN.

February 20.—ANCIENT CIVILIZATIONS IN AMERICA. Prof. JOHN S. NEWBERRY.

March 20.—SOME RESULTS OF PHOTOGRAPHY AS APPLIED TO ASTRONOMY. Prof. JOHN K. REES.

April 17.—THE SUBMARINE TUNNEL BETWEEN ENGLAND AND FRANCE. Count ERNST VON HESSE-WARTEGG.

May 15.—GLACIERS. Prof. H. CARRINGTON BOLTON.

NOTES FOR "THE INTERNATIONAL TIME SYSTEM."

[1] See Proceedings of the American Metrological Society, p. 18, Vol. II., Part I. Report of Committee on Standard Time, and Vol. II., Part II., page 175.

[2] A full description of this unique system is given in the January number of the *Popular Science Monthly*, by Prof. E. Engler, of Washington University, St. Louis.

[3] See Reports of the Superintendent of the Naval Observatory, in the Washington Astronomical and Meteorological Observations.

January 23, 1882.

The President, Dr. Newberry, in the Chair.

The first of the regular monthly lectures of the course for 1882 was held in the large hall. The number in the audience was not recorded.

The President opened the course with a few brief remarks, and gave place to the lecturer of the evening, Prof. Benjamin N. Martin, of the University of the City of New York, who addressed the Academy on the following theme:

THE MORAL BEARING OF RECENT PHYSICAL THEORIES.

(ABSTRACT.)

The speaker maintained that the argument for the Divine existence from the adaptations discernible in nature has, with the recent progress of scientific ideas, undergone a great and essential modification. He quoted Paley's statement that no change takes place in an animal form from generation to generation. We do not, by running back through an indefinite series of ages, make any approach to accounting for the intelligence displayed in its construction; though if there were some slight gain at each step, we might by an indefinite series of generations, approaching nearer and nearer, account thus for the whole result.

The scientific opinion of Paley's day affirmed the fixedness of species; and, so long as that view was maintained, Paley's argument was unassailable. But now, Darwin has questioned this idea, and scientific opinion, in affirming the progressive development of species, has stricken away the foundation on which the teleological argument had

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Notes for "The International Time System."—*Continued.*

[4] See Annual Reports of the Director of the Astronomical Observatory of Harvard College.

[5] Reports of the Director of the Allegheny Observatory for 1872, *et seq.*

[6] Annals of the Dudley Observatory, 1866, *et seq.*

[7] Annual Reports of Director of Cincinnati Observatory, 1868, *es seq.*

[8] Pamphlet on "The Regulation of Time," etc. By F. A. P. Barnard, President Columbia College, New York City.

[9] Copies of St. Louis *Globe-Democrat* and St. Louis *Republican*, for January 11, 1881.

[10] See Proceedings of Am. Metrolog. Soc., Vol. II., Part I, page 24.

[11] Proc. Am. Met. Soc., Part II., Vol. II., p. 179. Standard Time-Circular No. 1.

[12] Am. Metrol. Soc. and Canadian Institute.

[13] The Penn. R.R. prints the time between 12 o'clock noon and 12 o'clock midnight with heavy faced type, besides putting in the designations A.M. and P.M.

Some of the railroads in the West have printed time-cards with the hours numbered from one to twenty-four. J. K. R.

[14] From a Pamphlet on "The Regulation of Time; International Coinage; The Unification of Weights and Measures; Sea Signals." By F. A. P. Barnard, S. T. D.

[15] Part of unpublished Report of Committee appointed to attend the Third International Geographical Congress, held at Venice, September, 1881.

been so confidently based. *Now,* what? This requires a consideration of recent scientific principles and an account of their bearing on theism.

The great results of scientific inquiry in our day are two, expressed each by a single word, EVOLUTION and CORRELATION. The first of these, evolution, is that the arrangements of nature are due, not to immediate acts of Divine creation, but to a process of slow development (1) from small beginnings, (2) by gradual changes, (3) through long periods, and (4) by the operation of natural forces.

This truth is no recent discovery of Mr. Darwin, though formulated by him in one department, but is the general characteristic of modern science. It is displayed (1st) in the great nebular hypothesis. This is simply an account of the development, through the process just described in its four particulars, of the astronomical system. Our own solar system discloses this as the method of its origin; the cosmical system illustrates the same process, and the nebulæ beyond alike suggest it. In this view all astronomers are now substantially, though with some variations, agreed.

(2d) Next: Geology manifests still more striking evidences of the same process of development. We can trace our globe downward from the condition of a fiery mass, on which water could not exist, to the formation of seas; in these the deposit of rocks—Archæan, Silurian, Devonian and the rest—took place according to the present laws of deposition; and still the process goes on to the present time, and gives us the whole body of the rocks with their elevations and depressions. In all this, geologists agree in finding the slow and gradual operation of natural forces.

Organic life is now claimed as falling under the same law; and thus we have almost the whole body of Science committed to the development theory.

This theory has two effects: 1st. It reduces all operation of creative power to a minimum; the changes at each point are insignificant: 2nd. It removes this minimum to the remotest period of time. The creative power may have formed germs, in the beginning; but for all else, the work of nature's forces will sufficiently account.

The other great scientific idea is that of the correlation or convertibiilty, of the Forces.

Working in quite a different sphere, and with no relation to the progress already described, Science has given us another change of views of altogether an opposite tendency. Phenomena are no longer ascribed to "fluids," as the electric, or the caloric, fluid. They are now conceived as due to molecular motions in things around us. "Heat," says Tyndall, "is a mode of motion;" and as clearer conceptions began to dawn upon the scientific mind, it was found that several of these groups of phenomena, which had originally constituted distinct sciences, are at bottom only varying modes of motion, occasioned by the varying conditions of action, of a single force. Magnetism, and Voltaism were found to be but variations of electricity: soon electricity began to identify itself with chemical affinity: heat and light were correlated with each other; heat, moreover, showed its relation to electricity in the phenomena of thermo-electricity. At length Faraday, with the aid of Whewell, entered upon an elaborate investigation, and showed satisfactorily that all these phenomena are due to one general and all-pervading force. All are mutually convertible: and hence we have the theory of the unification of nature, in the doctrine variously described as the Persistence of Force, and the Correlation or Convertibility of the Forces. All specific forces are simply phases of one. This one is without beginning or end, it pervades the universe; it has framed the systems of the heavens and the earth. As expounded by Herbert Spencer, it is "coördinate with all orders of phenomena;" and is the real and sole author of all the changes which take place around us—the ever present, ever active, unbeginning, and unending nature-force which carries on the working of the universe.

It results from this, that there is no real force but this of the infinite, and that every other and more specific force is but a transient phase of the acting of the First Cause.

This conception of an infinite and diffused force or power, carrying on, as it has originated, the system of nature, is the very opposite in tendency of the former. Correlation is the counterpart of Evolution. While the latter removes the creative action to the farthest limit of time, the latter brings it into the present operations of nature. While evolution reduces the divine action to a minimum, correlation makes it the only active and vital thing in nature; while evolution attributes everything to physical forces in all the bodies of the world, correlation abolishes the very existence of these forces as distinct realities, and makes the infinite the only real agency—the ever active cause of all nature's changes. We are, therefore, brought—by this doctrine of correlation—face to face with the infinite and the eternal.

It is the most elementary doctrine of physics that every action involves an equal reaction. When, then, you act, what force is it that reacts against you? Whatever may be its humble name, or its familiar aspect, it is simply the force of the infinite.

To some, this may seem to involve the danger of Pantheism; but we are shut up to it, whatever the danger. It only brings us back, however, to the familiar conception of Newton, that "the laws of Nature are the established methods of the Divine action;" and Newton was no Pantheist. The doctrine of "the convertibility of the forces," or, as others have preferred to state it, "the persistence of force," gives us a single infinite force as the life of the world; and this necessarily identifies itself with what the Christian calls God.

Spencer, indeed, maintains that we cannot know the infinite; but he himself calls it "the First Cause;" declares it is the vital agency in every change, and proclaims it "productive," and shows thus a clear knowledge of it in the weightiest possible relations.

Tyndall hesitates to speak thus plainly, and says: "I will not call him, or it, a cause or a power;" but silence is not philosophy. If there is this single and universal agency, the consequence follows that all nature's movement is due to this one great cause, which originally shaped the earth and formed the heavens.

Correlation lays the foundation for a belief in the theistic conception. We have but to prove the intelligence, and the moral and personal character of this infinite cause, and we have before us what Christ called the "Lord of heaven and earth;" and this, the familiar argument of Paley, and the rest of our teleological writers, enables us to do triumphantly.

In view of this great generalization, of one only force in the universe, the whole perplexing and obscuring maze of second causes and minor forces disappears—we are face to face with the infinite, with which alone we have to do. Thus, while Evolution seems almost to banish God from the creation, the profounder philosophy of Correlation restores this grand conception, and makes us feel that in very truth it is in the First Cause that "we live, and move, and have our being."

January 30th, 1882.

Section of Geology and Mineralogy.

The President, Dr. Newberry, in the chair.

Fifty-seven persons present.

The committee, consisting of the President and Recording Secretary, to whom had been referred the preparation of a memorial to the authorities of the State, regarding the completion of the volumes of the Geological Survey, reported the following resolutions, which were unanimously adopted by the Academy.

Whereas, A large amount of new and valuable material has been prepared by Prof. James Hall for the completion of his series of reports on the Palæontology of New York, many of the plates having been already engraved; and,

Whereas, The publication of this material would require only a relatively small appropriation, and would give to the public the fruit of large expenditures previously made,—is demanded by the honor of the State,—and would greatly facilitate the labors of every geologist in the country;—

It is therefore,

Resolved, That the best interests of the State of New York, and the credit and usefulness of science in America, would be advanced by the completion of the great work on the Palæontology of New York, continued through so many years under the supervision of Prof. James Hall; and,

Resolved, That the members of the State Legislature be, and hereby are, earnestly requested to make the necessary appropriations for the publication of the material already prepared, while it may have the benefit of the supervision of the distinguished palæontologist who has been the author of the preceding volumes; and,

Resolved, That a copy of these resolutions, signed by the President and Secretary of the Academy, be transmitted to the Governor of the State, and to the presiding officers of the Senate and Assembly.

O. P. HUBBARD. J. S. NEWBERRY.
Rec. Secretary. *President.*

THE PRESIDENT read a letter from MR. CHARLES W. LOVETT, of Centre Marshfield, Mass., regarding the rate of accumulation of salt-marsh deposits in eastern Massachusetts. At various points in his vicinity, MR. LOVETT reports the finding of bricks identical with those used for the chimney of the old Peregrine White house, buried beneath three feet of compact undisturbed marsh-soil. Wood cut by the civilized axe, and other articles, he also mentions as found at the same depth, and in like situations. The rate of growth seems to be general, and not local or accidental; and some clue may thus be gained as to the movement of the coast-level in this region.

DR. ALBERT R. LEEDS gave a brief account of the methods of formation and the properties of a number of new componnds of the organic aromatic bases, with the haloid and other salts of the metals. The resulting compounds are substances formed on the ammonium type, with as many hydrogen atoms replaced as would correspond with the valences of the metallic radical entering into combination. When certain of these compounds, such as the Di-phenyl-mercurammonium chloride, or cyanide, or the Di-tolyl-mercurammonium cyanide, are exposed, along with carbon bisulphide, to the action of sun-light or of heat, part of the sulphur in the carbon bisulphide unites with the metallic radical, hydrochloric or hydrocyanic acid is evolved, and Di-phenyl-sulpho-carbamide or Di-tolyl-sulpho-carbamide is formed.

MR. WM. EARL HIDDEN then read the following paper:

THE DISCOVERY OF EMERALDS IN NORTH CAROLINA.

Mr. President, Ladies and Gentlemen:

That emeralds have been found in the United States, has been doubted. The press has stated "the discovery of emeralds needed confirmation." It is my pleasure to show you this evening convincing proof of the existence in our country of this rare and beautiful gem. Since what the impetus was that started the search for emeralds in North Carolina would be of interest, I will give you the story, gathered as it is from a year's residence on the spot where the discovery was made.

Sixteen years ago, the site of the North Carolina emerald mine was covered with a dense primitive forest. Less than ten years ago the locality was mineralogically a blank, nothing was known to exist having any special interest or value. Whatever we know of it to-day, is due indirectly to MR. J. A. STEPHENSON, a native of the country, whose interest in mineralogy is a purely natural one.

Under a promise of reward, if successful, he had engaged the farmers to search the soil for crystals, Indian stone relics, etc., and for some years enjoyed surprising success in thus gathering specimens.

Every specimen found in this region proves to be a revelation to science. In some respects they were of more interest than anything heretofore found of their kind.

Certain it is that this region, and I state this from my own experience in collecting, has produced some of the most remarkable and beautiful specimens of Emerald, Spodumene, Beryl, Rutile and Monazite, thus far discovered in the United States.

To be brief and to the point, I will say, that in a few localities in Alexander county, crystals would be brought of the common opaque beryl; but now and then a semi-transparent prism, having a decided grass-green color, much resembling the famous crystals from Siberia, so familiar to mineralogists, would be found and offered for sale in the neighboring towns. Those came to have the name among the farmers of "green rocks" and "green bolts." From the fact of their selling for more than anything else they found, these green crystals became the ultimatum of their searching.

Among other curious local names for minerals were "Donicks" for quartz crystals, "Black Bolts" for prisms of tourmaline, "Red Metal" for rutile crystals, and "Needle Rock" for the beautiful sagenite, or Arrows-of-love stone.

Suffice it to say that in a period of about six years, there were found loose in the surface soil, on three plantations in this county, a small number of beryls having a color verging distinctly upon the true emerald tint, none of which crystals, however, were deep-colored or transparent enough for use as gems.

Some of these crystals were obtained by the Mr. Stephenson before mentioned. It was the sight of two of these "green bolts" which prompted me to visit the locality and make a search for the true emerald. I cannot understand why work was not commenced long ago, when such favorable signs were so common.

That such indications could receive only passing notice from collectors, is really inexplicable. A very natural conclusion would have been that where these pale emeralds were found loose in the soil, darker and purer ones would be found by mining for them.

Such inducements as the following were held out to the farmers to search for these "green bolts." A visiting collector had offered the munificent sum of *one dollar*, to farmers who should find a crystal as long as his finger, which must, to merit the dollar, be *dark green*, pure, transparent, and with perfect terminal planes and prismatic faces!

Such is the history of the emeralds found in Alexander county, before I commenced systematic mining for them.

The location of the mine was obtained in the following manner. A corps of workmen was employed to dig a series of deep ditches in directions that would cut the strata at different angles. The site chosen for work was on the spot where at least half a dozen pale emeralds had been found. This location was shown to me by the farmer who had discovered the specimens while plowing.

Not knowing then their manner of occurrence, I expected in this way to strike a vein bearing them. Five weeks were spent (in July and August, 1880) before any success was met with; and then, at a depth of eight feet was discovered a "blind vein" (so called because it had no outcrop), having very small emeralds. In this vein, or pocket, as it proved to be later, and outnumbering the emeralds fifty to one, was also found the new emerald-green mineral which was such a surprise to the scientific world, and which was destined to answer the same purposes as did the gem I sought. I refer to the spodumene-emerald, now known as Hiddenite.

You must pardon this digression, but the search for emeralds is so interwoven with my discovery of emerald-green spodumene that I cannot tell the story of one without the other. The two minerals occur intimately associated, and while mining for the one the other is constantly found.

This blind vein yielded very handsomely of the new mineral, but very sparingly of emeralds, and the few found were too small to be useful as gems, though their color was very good. A tunnel, for the purpose of drainage, 261 feet long, mostly through rock, was cut to this vein, and a shaft sunk down upon it. At this time the work on this vein has reached a depth of 36 feet, at which point it proved its pocket nature by pinching out—closing together.

Thus far, twelve of these pockets have been found within an area of forty feet square, carrying emeralds, four of which pockets contained also the spodumene-emerald.

All these veins maintained nearly the same character of dip, thickness, length and associations.

Other pockets were found that yielded Quartz, Rutile, Monazite, and Mica crystals of great beauty. Others yet, whose walls were covered with finely crystallized Dolomite, Calcite, Apatite (transparent and pellucid) Rutile, Pyrite, Quartz and Mica.

In one instance, a small pocket that contained two beautiful emerald crystals, had its walls covered with large crystals of Albite (twinned parallel to the basal plane). Another pocket contained only Mica crystals and one small pellucid colorless beryl that had both ends brilliantly terminated with many planes. I mention the above associations, that you may learn the diversity in these pockets, although they are so near together.

In the rock-mining, and while prospecting on the surface, the sign of a vein is the presence of small streaks of massive quartz, or of mica, in a counter direction to the strike of the country-rock, either of which lead to open pockets not many feet off. The gems have thus far been found loosely attached to the rock. Not over nine emeralds have been found at any one time. Mineralogists have a great treat in store for them, when deep rock-mining is accomplished here. Then the gems will be found firmly attached, and they will shine with all their primitive crystalline beauty.

The largest emerald found in this mine is 8½ inches long, and weighs nearly 9 ounces. It was one of nine fine crystals contained in a single pocket; their color was excellent, and they were transparent, though somewhat flawed.

The locality is situated about 35 miles, air-line measure, S. E. from the "Blue Ridge" mountains. The contour of the country is low rolling, and its altitude is about 1200 feet. The soils are chiefly red gravelly clays, of not much fertility. The prevailing rock is gneiss, with more of a feldspathic than a micaceous character: the trend of the strata is N. N. W. and S. S. E. with a dip nearly vertical.

The gems and crystals occur in open pockets (miniature caves), of very limited extent, these are cross fractures or fissures in the rock. These fissures, lenticular in shape, are usually nearly perpendicular.

There being no glacial drift here, the soils are necessarily the result of decomposition and disintegration on the spot. It is therefore an easy task to find the source of minerals found on the surface. The "*frost drift*" theory of Prof. Kerr is everywhere proven in this region. He well says that "to a foreign geologist, entering the South Atlantic States for the first time, a hundred miles or more from the coast, the most striking and novel feature of the geology is the great depth of earth that everywhere *mantles and conceals the rocks.* This is readily discovered to be, for the most part, merely the result of the decomposition *iu situ* of the exposed edges of the underlying strata. The vertical and highly inclined bedding-lines of strata, *are distinctly traceable by the eye, through this superficial earth covering, and are seen to pass by insensible gradations into the undecayed rock beneath.*" At this locality, the unaltered rock is found at a depth of twenty-six feet, and is of unusual hardness, especially where it walls the gem-bearing pockets.

Thus far the gems have been found in a narrow belt running N. E. and S. W., and scattered over a distance of three miles. In this belt, signs of cross-fissures are very abundant, and it is a very common thing to find crystals of quartz, rutile, tourmaline, etc., etc., *perfectly preserved,* scattered over the surface.

A peculiar feature pertains to most of the emeralds and beryls from this region. They appear as though filed across the prismatic faces. The basal plane is also often pitted with minute depressed hexagonal pyramids, that lie with their edges parallel to one another, and to the edge of the di-hexagonal prism. Rarely, though, crystals are found with perfectly smooth and brilliant faces. The emerald color is often focused on the surface, and fades gradually to a colorless central core, which feature is of exceeding interest when the genesis of the mineral is considered. The emeralds have been found of richer color, and less flawed, as the mine gets deeper. [These points were illustrated by a beautiful series of specimens.]

In regard to the commercial value of the emeralds thus far found, I will frankly state that the majority of the crystals have little value for gem purposes; but as cabinet specimens they are unprecedented, and as such have a market value ranging from $25 to $1,000 each.

From the largest crystals, stones of over one carat weight could be cut, that would be marketable as gems; but as scientific specimens, the crystals in their entirety would have greater value. Certainly no better signs could be wished for than these specimens, to prove the existence at this locality of dark-colored crystals, pure enough for cutting into valuable gems.

This region has a great future as a gem-producing district. Mining skill and capital are the only essentials needed to insure success. It may be interesting to note that the entire expense of the work at this locality has been more than repaid by the sales of the gems (Hiddenites) discovered. But for the liberal financial aid given to the writer by both Mr. RICHARD H. ROBERTS, of Albany, and Mr. JAMES D. YERRINGTON, of Cresskill, N. J., the work of discovery and development at this locality would have been very much retarded, if not indefinitely postponed.

DISCUSSION.

Dr. NEWBERRY remarked on the extreme beauty of the specimens exhibited by MR. HIDDEN, and the great interest of these discoveries, in which he had achieved such signal success, both practical and scientific.

Dr. R. P. STEVENS made some further remarks on the communication, comparing the aspect of the specimens, and the mode of their occurrence, with those of the emeralds from the celebrated locality near Bogota. He referred to the fact, also, that the Bogota mines had been worked by the early aborigines, and were doubtless the source of the emeralds described with so much enthusiasm by the Spanish historians of the conquest of Peru.

Mr. GEORGE F. KUNZ exhibited a remarkable series of prehistoric knives, flakes, and cores, of Obsidian, from the vicinity of the city of Guatemala, Central America. They were obtained by the partial cutting away of a mound, during the making of a new road, about six miles from the city. The excavation revealed a sort of little cyst or chamber, walled and roofed with slabs of stone or baked clay, within which this large quantity of obsidian knives had been carefully and quite regularly laid away. There was scarcely anything else in the chamber, but the broken and worn edges of many of the implements would indicate that they had been much used; and the suggestion is strong that this may have been a sacrificial mound, and that these were the implements used in the rites of sacrifice, perhaps for a long period.

Feb. 6, 1882.

REGULAR BUSINESS MEETING.

The President, Dr. J. S. NEWBERRY, in the Chair.

Forty-five persons present.

The following named gentlemen, on recommendation of the Council, were elected resident members:

A. D. CHURCHILL. JOHN TOWNSEND.

The Committee appointed at a previous meeting, to prepare resolutions appropriate to the recent death of Dr. J. W. DRAPER, reported the following minute, which was read by Prof. D. S. MARTIN:

WHEREAS, The recent death of Prof. John W. Draper has removed from among us one of the oldest and most distinguished members of the Academy, and one of the most eminent original investigators in the realm of physical science; therefore,

Resolved, That the Academy would hereby express its profound appreciation of the high attainments and honorable services of our late associate, and its sense of sorrow and loss in his departure from our sphere; and that we cannot suffer this event to pass without a brief tribute to his revered and cherished memory.

Prof. John William Draper was born in 1811, at St. Helens, near Liverpool, England. Having received a thorough preliminary education, he was sent to the newly-opened London University, in 1829, that he might study chemistry under Dr. Turner. Urged by relations, he came to America in 1833, and soon afterwards began the study of medicine at the University of Pennsylvania, from which he was graduated in 1836.

Immediately after his graduation, Dr. Draper went to Hampden Sidney College, as Professor of Chemistry and Physiology, to which chair he had been elected before receiving his degree. There he began that remarkable series of investigations which ended only with his life, and which has had so important a bearing on the progress of discovery in several branches of physics. The results of his earlier researches were published in the *American Journal of Science* and in the *London Philosophical Journal*; and, together with later discussions, were collected into one quarto volume, which was published in 1844, under the general title of *The Chemistry of Plants.*

The interest awakened by these earlier investigations secured for Dr. Draper the appointment of Professor of Chemistry and Physiology in the University of the City of New York. He was originally assigned to a chair in the Medical Department, but owing to the financial disaster of 1837, the Medical School was not organized at once, and Dr. Draper began his work in the Collegiate Department of the University, in 1839. He remained in the discharge of his duties until within a few months of his death.

To Dr. Draper is due, in a great measure, the prominence of New York City as a centre of medical education. Previous to 1840, the number of students attending the Medical School seldom exceeded fifty, and oftener fell below. But in that year the Medical Department of the University was organized, and under the management of Dr. Draper, as Secretary of the Faculty, classes of almost 150 students were graduated. The existence of the school was imperiled in 1865, when fire destroyed its building, with the museum and apparatus; but Dr. Draper succeeded in obtaining temporary accommodations, and the exercises went on without the loss of a single day. Dr. Mott resigned the Presidency of the Medical Faculty in 1850, and was succeeded by Dr. Draper, who retained the position until 1873, when he resigned it in order to devote himself wholly to his duties in the Collegiate Department.

Dr. Draper's lectures on physiology were as eloquent as they were original, and reflected well his daily work as an investigator. They were published in 1856 as a *Treatise on Human Physiology*, which was recognized at once as a substantial contribution to the rapidly developing science of which it treated. This work was the record of observations covering more than twenty years.

The *History of the Intellectual Development of Europe* was but the outgrowth of the work on physiology—a grand expanding of its second portion. It is familiar to most of us, and needs neither description nor discussion here. Soon after the publication of this work, Dr. Draper began the preparation of a *History of the Civil War in America*, which was published in three large volumes. During its preparation he enjoyed exceptional advantages.

After completing the *History of the Civil War*, Dr. Draper returned to those physical studies of which the continuity had been interrupted by his literary labors. During the last ten years of his life he revised his earlier publications, and gave them in condensed form under the title of *Scientific Memoirs*. In these he included also the results of investigations conducted during the preparation of this volume, some of which were of cardinal importance.

It would be difficult to over-estimate the value of Dr. Draper's labors, which are interwoven with the progress of scientific discovery during the last forty years. He was the first to take the human portrait by light, and he was the first to discover and to photograph the lines below the red in the spectrum. He laid the foundation on which Bunsen and Kirchoff reared a noble superstructure, without much regard to the master builder who had preceded them in the work. Of his discoveries in physiology, the most important were made so long ago that they have now become incorporated into the science so fully that the name of the discoverer is rarely mentioned in connection with them.

This Academy should hold the memory of Dr. Draper dear to it. Soon after reaching New York he became an active member of the Academy, then the Lyceum of Natural History. Many of his earlier results were first announced in its meetings, and the proofs of his discoveries were deposited in its collections. When misfortune overtook the Lyceum, when it was deprived of a shelter for its collections and was without a place for its meetings, and when most of its members were ready to desert the organization or to dissolve it, Dr. Draper procured for the Society the privilege of depositing its collections in the building of the University Medical School, and of holding its meetings in the faculty-room of the same building. It may be said that the continued existence of the Lyceum was due solely to Dr. Draper's efforts in that crisis of its history.

Dr. Draper was a diligent student in many fields of research. The great fund of knowledge thus acquired made him rich in illustration, and gave to his writings an eloquence peculiarly his own. He was an ingenious and persistent investigator, with an acuteness of perception which rarely failed to grasp the bearings of facts. He was an earnest and patient instructor, full of a magnetism which attached his pupils to him and awakened an interest in the science which he taught. He was unassuming in manner, but possessed of an indomitable will, and was actuated by a delicate sense of honor in all dealings with his fellow men.

Dr. Draper is gone from among us, but his works will survive him. The field of investigation in which he stood almost alone, forty-five years ago, has now many devoted workers, through whom each year will bring fresh additions to his fame.

Resolved, That this minute be published in the Transactions of the Academy.

JNO. J. STEVENSON,
DANIEL S. MARTIN, } *Committee.*

The resolutions, as read, were unanimously adopted by the Academy.

Notice was given to the Society of the death, since the last meeeting, of Dr. A. L. HOLLEY, one of its Fellows; and, on motion of Mr. ARTHUR H. ELLIOTT, that a Committee be appointed to prepare a similar minute in regard to Dr. HOLLEY, the President named Prof. T. EGLESTON and Mr. ELLIOTT as such Committee.

Prof. A. R. LEEDS exhibited a fine specimen of Natrolite, from the new tunnel now in progress through the Bergen Hill.

Mr. G. F. KUNZ showed a remarkably large crystal of Arkansite, from Arkansas; and also a peculiar hydro-carbon mineral from near Milan, Lombardy, which bore considerable resemblance, in several respects, to the peculiar coal-like peat discussed by Prof. FAIRCHILD at the meeting of Dec. 19th.

Prof. J. S. NEWBERRY then presented the paper of the evening, entitled

THE ORIGIN AND RELATIONS OF THE CARBON MINERALS.

The following is a brief synopsis of the paper, which will appear in full in the Annals of the Academy:

(Abstract.)

1. The so-called "carbon minerals," peat, lignite, coal, anthracite, graphite, petroleum, etc., are not, properly speaking, minerals, as they are without definite chemical formulæ or crystalline forms. They are groups of organic substances, vegetable or animal, the products of progressive changes incident to their nature and reaching their inevitable end in complete oxidation.

2. The principal source from which these substances are derived is vegetable fibre, which consists of organic tissue with a variable quantity of inorganic matter woven into its composition, which remains after oxidation, and is called ash. The organic portion consists, in round numbers, of carbon fifty per cent, oxygen forty-two per cent, hydrogen six per cent, nitrogen two per cent. Like all organic matter, this has been formed under the influence of the vital force, in antagonism to the affinities of inorganic chemistry; and when abandoned by this creative and conservative force, it is necessarily, though more or less slowly, oxidized. When very rapid, this change is called combustion; when less rapid, decay; and when operating very slowly, it becomes a kind of distillation, in which the constituents react upon each other, forming definite or indefinite compounds that retain the solid state or assume liquid or gaseous conditions. In the progress of this change to complete oxidation, an equal amount of force is evolved with that absorbed in the growth of the organic structure. By controlling the exhibition of this force, we utilize it in the form of heat, light, motive power, etc.

3. The changes which take place in organic tissue result in the formation of two classes of products—*residual* and *evolved*. The residual products of the spontaneous distillation of wood-tissue are solids, which are grouped under the conventional and undefinable names of peat, lignite, bituminous coal, semi-bituminous coal, anthracite, graphitic anthracite, and graphite. The evolved products are carbonic acid, carbonic oxide, and numerous hydrocarbon and nitrogenous gases, and the liquids water and petroleums. From the latter, by a kind of spontaneous distillation, are derived non-oxidized solids, paraffine, ozokerite, etc., and oxidized solids, asphalts. From these last are derived asphaltic coals, Grahamite, Albertite, etc.

4. The residual products are portions of a continuous series, beginning with wood-tissue and ending with the ash or inorganic portion left when the organic matter is distilled away, each group showing

considerable diversity of composition, and graduating insensibly into those above and below.

5. The evolved products are given off in all stages of the progressive change. They, too, are usually mixtures when eliminated, and are constantly changing by the absorption of oxygen and conversion into their final state, carbonic acid.

6. The escape of the evolved products is constantly taking place from all great accumulations of carbonaceous matter; the gases commonly and the liquids occasionally are seen escaping from beds of coal; and both abundantly from the much greater accumulations of carbonaceous matter in bituminous shales, gas and oil springs being inseparably connected with the outcrops of all these great deposits. Coal and petroleum also spontaneously change when exposed to the air, the coal rapidly losing its volatile constituents, and with them its value for the manufacture of gas and coke; petroleums becoming by evaporation and oxidation thicker and darker, finally forming asphalt, or without oxidation, paraffine, ozokerite, etc.

7. The differences which we observe in the residual and evolved products are in part due to peculiarities in the organic tissue from which they are formed, and in greater degree to the stage of distillation that they have reached. Different kinds of vegetation, as oaks, pines, ferns, algæ, etc., having somewhat different compositions, yield diversified products in distillation; and petroleums, though mainly derived from cellular plants (seaweeds, etc.), are in part the products of the distillation of animal matter, and owe some of their characteristics to that fact.

8. Every step in the process described above is abundantly illustrated in our coal and oil fields, all of which have been studied by the speaker. The views presented are not the coinage of the imagination, but a simple transcript from nature; and they are sustained by such an array of facts as to compel their acceptance. Instances were given of the conversion of lignite into coal, anthracite and graphite, by volcanic action, and of the natural derivation of asphalt, asphaltic coals, and anthracite, from petroleums.

9. Further the great work going on in nature's laboratory may be closely imitated by art; the differences in the results being simply the consequence of differing conditions in the experiments. Vegetable tissue has been converted artificially into the equivalents of lignite, peat, anthracite and graphite, with the emission of vapors, gases and oils, closely resembling those evolved in natural processes. So petroleum may be distilled to form asphalt, and this in turn converted into Albertite and coke (*i. e.*, anthracite). Grahamite has been artificially produced from petroleum by Mr. W. P. Jenney.

10. The theories proposed by Berthelot, Daddow, Byasson, and Mendelejeff, for the genesis of petroleum, are the results of speculation in the study or irrelevant experiments in the laboratory, and have no confirmation or illustration in the facts of nature.

February 13, 1882.

SECTION OF PHYSICS.

The President, Dr. NEWBERRY, in the Chair.

Forty persons present.

Prof. ROBERT H. THURSTON read a paper,[1] entitled

ON THE BEHAVIOR OF STEAM IN THE STEAM-ENGINE CYLINDER, AND ON CURVES OF EFFICIENCY.

(Abstract.)

In an earlier paper[2] the writer had shown what are the conditions determining the ratio of expansion in steam engines working at maximum efficiency, and how those conditions vary in different types of engine, and also how essentially different is the actual working engine, in all that effects that ratio, from the hypothetical case usually taken, in which the steam is assumed to expand adiabatically in a non-conducting steam-cylinder. It was finally shown what were the best values of this ratio for several standard types and representative cases, as determined by the writer by direct observation and by the study of experimentally obtained results, the precise figures given being obtained by rules of simple form so deduced.

It was shown that first friction and then—often to a vastly greater extent—cylinder condensation, due to expansion of a heated fluid in a working cylinder made of a material of high conducting power, modify the methods of expansion and of expenditure of heat so greatly that the ratio of expansion for maximum efficiency, in unjacketed engines, rarely exceeds $\frac{1}{2}\sqrt{P}$, where P is the gauge pressure in pounds per square inch, although its value would otherwise be, often, several times greater. It was also shown that these modifying conditions very differently affect different kinds of steam engine, and different engines, and also individual engines, at various pressures and piston speeds.

In this paper it was proposed to show more fully what is the behavior of steam in the steam-engine cylinder and to exhibit the form taken by the expansion-line; to give values of mean pressures obtained under

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[1] Published in full in the Journal of the Franklin Institute, February, 1882.

[2] On the Ratio of Expansion at Maximum Efficiency in Steam Engines; Trans. Am. Soc. Mech. Engrs., 1881; Jour. Franklin Institute, May, 1881.

various conditions, and finally, to show the method devised by the author for laying down curves of efficiency, and to show what conclusions follow from their study.

It was shown that in no case, in steam engines as to-day constructed, can the expansion-line or the curve of mean pressures be such as would be obtained in a non-conducting cylinder. Steam must always be more or less condensed at the beginning and must always carry away heat by its re-evaporization at the end of the stroke. The steam-jacket checks the first operation, but accelerates the last, and, with wet steam, may scarcely decrease the evil that it is designed to prevent.

It was stated that the adiabatic curve may be closely represented by a regular curve of the hyperbolic class, $p_1 v_1^n = p v^n$, the exponent n varying with the proportions of steam and water in the mixture at the commencement of the expansion, which is assumed to take place in a non-conducting cylinder. Zeuner finds the value of n to be nearly $n = 1.035 + 0.1 x$, x being the proportion of steam present.

Table I, appended to the paper, gave the values at the ratio of mean pressure to initial pressure $\frac{p_m}{p_1}$, for various mixtures from steam 1.00, water 0, to steam 0.50, water 0.50, assuming the formula to be practically accurate within that range.

With these are given the adiabatics for superheated steam, $n = 1.333$.

Table II gave the values of $\frac{p_m}{p_1}$ for steam-expansion in a jacketed metal cylinder, in which it is kept just dry and saturated by heat from the jacketed sides and ends; the values for wet air compressed in air-compressors, in which n is frequently found to be 1.2; and for peculiar cases in actual steam engines in which leakage or re-evaporation, or both, raise the terminal pressures greatly, giving $n = 0.50$, $n = 0.75$.

It is, as yet, impossible to predict which of these curves will be found in ordinary engines, and the engineer is compelled to rely entirely upon the "indicator" for information of this character; this instrument gives him a more or less exact graphical representation of the changes of pressures and volume throughout the stroke. The greatest possible variety of curves are found to occur in such cases, but they approach the adiabatic more nearly, as the steam is drier and, as the speed of piston is increased, rarely departing far from the common hyperbola in good engines.

The values of $\frac{p_m}{p_1}$ given in the tables are plotted on Plates I and II, and from these a better idea can be obtained of the method of variation of mean pressure and of work done with variation of the ratio of expansion, and a better notion of the relation of these several curves gained, than by the study of the tabled quantities.

The writer next describes the curves of efficiency, of work and of mean pressures, to be obtained where steam is expanded in a non-conducting cylinder. They are easily deduced and easily constructed, and, by reference to Zeuner's formula, the engineer can determine them with a satisfactory degree of accuracy for all cases likely to arise in his practice.

Next, studying the behavior of steam in a metallic cylinder, he finds vitally different conditions and results; but given the law of variation of composition of the mixture with change of point of cut-off, or of ratio of expansion, it is, nevertheless, not only practicable but easy to determine curves of efficiency and to deduce values of the best ratio of expansion for any given case.

Where direct experience can be resorted to, to determine the cylinder condensation, it is easy, as shown later, to obtain *exact* results when seeking the ratio of expansion at maximum efficiency of fluid, of engine, or of capital, or in the solution of a rarer case which requires that the point of cut-off which gives most work for a given expenditure on the whole plant be determined.

The author describes and illustrates the construction and application of curves of efficiency for real engines, in the solution of important problems, and concludes by summarizing his work and leading the reader to the final deductions :

"The curve of variation of efficiency above traced, of which the abscissas measure varying quantities of steam used in a given steam-cylinder, while the ordinates are proportional to the quantities of work done by those amounts of steam, is a curve of entirely different character and form, and often widely different in location, from the curve of adiabatic mean pressures or other curve of mean pressures exhibiting the work done by various quantities of steam expanding under given fixed conditions in a non-conducting vessel.

"That no predetermination of the efficiency of any proposed engine, whether of fluid, of machine, or of capital, can be made unless the true curve of efficiency can be obtained for the assumed case.

"That the most certain and the most satisfactory solution of any problem of efficiency will be that obtained by first securing the elements of the curve of efficiency from actual engines operated in the manner proposed for the case taken.

"That having obtained by experiment upon any engine, the 'curve of efficiency,' as defined by the writer, the efficiency of fluid, of engine, and of capital expended to do a given amount of work, and the quantity of work to be obtained most cheaply from a given engine, may all be obtained for any given set of conditions, and the ratio of expansion at maximum efficiency, of fluid, of engine and of capital, and the ratio of expansion which, with a given plant, gives most work for a dollar of expense of operation, may all be determined with a degree of exactness only limited by the magnitude of the errors of observation.

"That the necessity of following the direction of improvement pointed out and entered upon a century ago, by Smeaton—the protection of the working fluid from losses of heat, by surrounding it with non-conducting surfaces—constitutes the most imperative of all demands to-day upon the mechanical engineer engaged in designing steam engines."

Prof. W. P. TROWBRIDGE made some remarks on the paper of Prof. THURSTON, expressing his high appreciation and interest, and treating of the importance of the subject.

Professor CHARLES F. HIMES, of Carlisle, Pa., presented the following paper, which in his absence was read at his request by Mr. W. LE CONTE STEVENS:

STEREOSCOPIC NOTES.

The interesting and exhaustive papers lately written by Mr. W. LE CONTE STEVENS have recalled corroborative experiments in a similar direction, made by myself about 1860, while critically examining the brochure[1] published by Sir DAVID BREWSTER, which did so much in connection with the lenticular stereoscope devised by him, and the rapid multiplication of photographic slides for it, to popularize the beautiful discovery of Wheatstone. By experiments with large photographs, specially prepared, without instrumental assistance, I found, as Mr. Stevens has in his experience, that convergence of the optic axes to a positive point was altogether unnecessary for the production of stereoscopic effect, as published in 1862 and subsequently,[2] and therefore that the binocular criterion of distances, as so clearly enunciated by Bishop BERKELEY in his *Theory of Vision*, must consist in movement of the optic axes successively converged on different points of an object, rather than in the degree of convergence of the axes.

At the same time, while experimenting upon the application of the stereoscopic principle to the solution of some scientific and metaphysical problems, I was led to discard the rather complicated and unsatisfactory diagram suggested by Sir DAVID BREWSTER for the explanation of the *Phenomenon of the Horizontal Moon*,[3] as well as the somewhat better one suggested by Professor RUETE,[4] and to

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1 The Stereoscope, London, 1856.

2 Am. Jour. Phot., Sept. 1, 1862; Journal of the Franklin Institute, Phila., Vol. XCII. (1871), Nos. 549, 550, 551; Vol. XCIII., Nos. 553, 556, 556, 558.

3 The Stereoscope, p. 201.

4 Das Stereoscop, Leipzig, 1860, p. 86.

substitute one more in accordance with the theory of rapid successive convergency of the optic axes in the estimation of distance. The effect was a decided surprise in its illustration of the phenomenon, but even more so as a corroboration of the theory. It consisted simply of two concentric circles, respectively 1⅝ inch and ⅞ inch in diameter as the left-eye picture, and a circle 1⅝ inch in diameter, enclosing two circles ⅞ inch in diameter each, with their centres respectively 1-10 inch to the right and left of the centre of the large circle, as the right-eye picture, the centres of the large circles being about 2⅝ inches apart. The expectation was, that the successive combination, so to speak, of the small circles of the right-hand figure, could at least be made so rapidly that a comparison of the sizes could be made at the varying apparent distances. The apparent *simultaneousness* of the appearance of the near and remote circles, with the expected difference in apparent size, constituted the surprise, which has been experienced by every one upon examining such a slide for the first time. Attention was called to the diagram in a published discussion of some of Sir DAVID BREWSTER'S views of the theory of the stereoscope in 1864, in the *British Journal of Photography*; and subsequently a dealer in stereographs placed it among his slides; but it is more than possible that even those interested in this subject may not have met with it, and I have therefore presumed to call attention to it in connection with the very interesting articles upon the subject before alluded to.

CARLISLE, Pa., January 30, 1882.

Mr. STEVENS exhibited the stereograph described by Professor Himes, and by large diagrams on paper explained the difference between this and Brewster's method of illustrating the phenomena of the horizontal moon. In addition, he remarked substantially as follows:

"It gives me much pleasure to present this paper by Professor HIMES, and to call attention to his careful observations on the nature of binocular vision, which were made twenty years ago, and have not received the full notice to which they were properly entitled. The great name of Sir DAVID BREWSTER carried with it a degree of authority which caused the general acceptance of the geometric theory of binocular vision. Professor W. B. ROGERS,[1] in this country, had also written a series of very able papers, in which he calculated what must be the form of the externally projected binocular image, assuming each point of this to be determined by intersection of visual lines. Professor HIMES discovered that such intersection is not necessary; but, unfortunately, his paper on this subject was not published in the *American*

1. Am. Jour. Science, vols. XX. and XXI., 1855 and 1856.

Journal of Science. (Mr. STEVENS here read an extract from the original paper, published by Professor HIMES, in the *American Journal of Photography* for September 1, 1862.) Shortly before the appearance of this paper, two Germans, ROLLET and BECKER,[2] published a method of securing binocular fusion of similar images with optic divergence, the possibility of such fusion having been already mentioned by BURCKHARDT. Professor HIMES' experiments were doubtless contemporaneous with those of the Germans just named, and were wholly independent of them.

"My own discovery of the possibility of stereoscopic vision by optic divergence was likewise independent. I subsequently learned of the previous experiments on this subject by ROLLET, BECKER, and HELMHOLTZ, and duly credited them in my paper before this Academy on the 6th of last June. Professor HIMES' papers were sent me after mine had been published in the *American Journal of Science* for last November. He deserves the credit of being the first in the country to secure stereoscopic vision with conscious optic divergence. My own claim is based rather upon the analysis than the discovery of this mode of stereoscopy. For years past, oculists have subjected their patients to the use of prisms for the purpose of testing the strength of the external rectus muscles of the eyeballs, in diverging the visual lines while the eyes receive, from an object in front, rays of light that are refracted by transmission through the glasses. In view of this fact, it is remarkable that BREWSTER'S geometric theory of stereoscopic vision should still hold its place in our text-books of physics. His theory of color has been abandoned, and his theory of binocular perspective is awaiting the same fate.

"In regard to the phenomenon of the apparent enlargement of the moon when seen at the horizon, Professor HIMES' stereograph gives an excellent illustration, superior to that of BREWSTER,[3] because the two parts, which are to be contrasted in the external projection of the binocular image, are more nearly aligned, and no motion of the stereograph is necessary. While the angular diameter of the moon remains nearly constant, being slightly greater when near the zenith, because the observer's true distance is diminished by nearly the earth's semi-diameter, its apparent magnitude varies with its estimated distance, and it appears much smaller when near the zenith, instead of larger. The cause of this illusion of distance, producing an illusion in regard to size, which is well illustrated by the present stereograph, has been the subject of much discussion. In so late a book as LOCKYER'S *Astronomy*,[4]

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2. Helmholtz, Optique Physiologique, pp. 827, 828.
3. The Stereoscope. London, 1856, p. 201 *et seq.*
4. Elements of Astronomy, Appleton & Co., N. Y., 1873, p. 116.

(1873), it is attributed to unconscious comparison with terrestrial objects at the horizon. If such be sufficient, there should be no apparent enlargement when the rising moon is seen upon a calm ocean ; but this is the condition under which the phenomenon is really most striking. For the following brief sketch of the views that have been held, I am indebted mainly to HELMHOLTZ.[5]

The first opinions put forth on the perception of the third dimension in space were in connection with these differences of apparent size of the moon.

PTOLEMY (A.D. 150) said that the mind judges of the size of objects in accordance with the previous appreciation of their distance ; this would appear greater when there are many intervening objects, since this occurs when the heavenly bodies are near the horizon. Nevertheless, he elsewhere attributes the enlargement to the refraction of rays by vapors.

ALHAZEN (1038) refutes the latter opinion and returns to the first. He is followed by ROGER BACON, and opposed by BAPTISTA PORTA.

VITELLION (1271) accords with ALHAZEN, and observes additionally that the whole celestial vault appears more elongated horizontally than toward the zenith.

KEPPLER (1604), whose opinion was adopted by DESCARTES, said that the distance between the two eyes is the base which we employ in measuring the distance of objects. We have here the first enunciation of the binocular theory afterward so emphasized by BREWSTER. KEPPLER adds that since, in making measurements with the two eyes, we learn to make them with the single eye, the magnitude of the heavenly body, as perceived in the eye, would serve as a base for distances relatively slight. We furthermore appreciate different degrees of light, and practically compare the size of an object with its distance, since we know by experience how much to extend the hands or to advance toward an object to touch it. KEPPLER thus knew the most important elements of the appreciation of distance, aside from that of dissimilarity of images.

The subject has been further considered by GASSENDI (1658), HOBBES (d. 1679), MOLYNEUX (1687), DE LA HIRE (1694), PERE GOUYE (1700), BERKELEY (1709), R. SMITH (1728), LOGAN (1736), DESAGULIERS (1736), BOUGUER (1755), PORTERFIELD (1759), SAMUEL DUNN (1762), MALEBRANCHE (1764), LAMBERT (1765) and EULER (1768).

The opinions expressed by these writers need not be repeated, except to say that BERKELEY insisted upon the dim and pale aspect of

5. Optique Physiologique, p. 870 *et seq.*

the moon at the horizon, attributing the judgment of increased distance to aerial perspective, as it is viewed through a thicker bed of air. This is unquestionably one of the most important elements, but BREWSTER[6] specially denies its value in the present case. Dr. R. SMITH made a series of estimates, sometimes toward the horizon, sometimes toward the zenith, and found that the distance of the horizon appeared from three to four times greater than that of the zenith.

HELMHOLTZ[7] gives reasons why the celestial vault should appear flattened, even though there is no such limiting surface to the space overhead. The path of the visible moon is referred to this imagined semi-ellipse; and to this circumstance, combined with aerial perspective, is mainly to be referred the illusive judgment of variation in its distance.

This illusion is by no means confined to our estimation of the distance of heavenly bodies. Most persons have probably observed the apparent magnification in distance of the ground when viewed from a lofty window compared with that of the window when viewed from the ground. In this case aerial perspective can scarcely be considered, and there is nothing to produce the illusion of a geometrically regular surface below. It seems highly probable that physiological rather than mathematical conditions are operative in producing the illusion."

Mr. W. LE CONTE STEVENS exhibited

A NEW REVERSIBLE STEREOSCOPE.

The objects to be attained in constructing this stereoscope were —

I. To secure ready motion to the semi-lenses, so that they may be adapted in position for any pair of eyes, whatever may be the interocular distance, and for any stereograph, whatever may be the stereographic interval within the usual limits.

II. To secure ready motion to the screen, so that the whole stereograph, or either separate half of it, may be visible to each eye, at will.

III. To secure the possibility of removing the semi-lenses, so that they may be reversed in relative positions, or be substituted by prisms with their bases toward each other, so that the left and right pictures may be simultaneously viewed, without discomfort, by the right and left eyes respectively, thus securing reversion of relief in the binocular image, if desired.

IV. To secure the means of examining the binocular image either alone or attended by monocular images, so that the difference between the two kinds of vision may be noted.

V. To secure the means of using the same instrument, either with

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6. The Stereoscope. London, 1856, p. 201 *et seq.*

7. Optique Physiologique, p. 800 *et seq.*

glasses or for binocular combination of images by direct vision, and to reduce the difficulty usually attendant upon stereoscopic vision by the latter method.

VI. To secure the means of producing stereoscopy from perfectly similar pictures by making the retinal images of these dissimilar.

The construction and manipulation of the instrument was illustrated in full; but a description of this is not given in the present abstract, because already furnished to the *American Journal of Science.* A printed description also accompanies each instrument, as issued by the manufacturers, Messrs. E. & H. T. ANTHONY & CO., 591 Broadway.

The feature in binocular vision, mentioned in paragraph VI. above, has not been explained hitherto, and has been but rarely perceived. If an object possessing three dimensions in space be held within a short distance and viewed alternately by the right and left eyes, the retinal images of it at these different standpoints are necessarily dissimilar. On this principle depends the whole art of stereoscopy, as illustrated with the instruments and stereographs in ordinary use. Each of the latter consists of two pictures of an object, taken from different points, so as to secure dissimilarity. The binocular combination of their retinal images hence presents the appearance of solidity, independently of any perspective effect secured by art.

If a large plane surface, on which are drawn similar figures regularly recurring at equal distances apart, be appropriately viewed with very strong cross vision, so that a phantom image, reduced in size, is seen in mid-air, the latter appears slightly curved, with the convexity toward the observer. This mere fact was first noticed by Sir DAVID BREWSTER, but on his theory of visual triangulation, the phantom image should be a plane, parallel to the given plane. The appearance of any convexity would disprove his theory, and BREWSTER undertook no explanation of what was to him, under the circumstances, probably not a striking phenomenon. This long-forgotten peculiarity of the phantom image, or at least its curvature in one direction, has lately been rediscovered by Professor LE CONTE, and its curvature in all directions by myself. It was at first regarded as one of the consequences of strong convergence of visual lines. By using, instead of a large plane surface, a card on which the two pictures are perfectly similar, such as a pair of series of concentric circles, and cutting the two halves apart, the horizontal visual lines may be made parallel while the two small cards are oppositely inclined to them, at any desired angle, by rotation about a pair of vertical axes. Each plane may thus bear to the visual line that meets it the same relation that would result from strong convergence or divergence in viewing a single continuous plane. The binocular effect is that the combined surface appears convex or concave, at will, by varying the angle formed by the planes of the cards on which the pictures have been have made.

Mr. STEVENS proceeded to explain and illustrate these effects in a series of diagrams, showing how this curious and novel result is due to the fact that, through the crystalline lenses, the images of the similar drawings, obliquely viewed from opposite sides of the normal to each picture, are projected upon retinal surfaces which are not planes, but nearly spherical, and hence are slightly dissimilar.

The full description of the reversible stereoscope, and the geometric discussion of the new method of stereoscopy, may be found in the *American Journal of Science* for March and April, 1882, the *London Philosophical Magazine* for April and May, 1882, and the *Popular Science Monthly* for May and June, 1882, in which latter it will appear as an illustrated article.

Feb. 20, 1882.

LECTURE EVENING.

The President, Dr. NEWBERRY, in the Chair.

The hall was completely filled.

Mr. WM. E. HIDDEN exhibited an extraordinarily large crystal of Monazite, from North Carolina.

The second lecture of the regular monthly course was then delivered, by Dr. J. S. NEWBERRY, upon

THE ANCIENT CIVILIZATIONS OF AMERICA.

(Abstract.)

Two distinct civilizations have left their traces in different parts of North and South America: 1. That of the Mound-Builders in the Mississippi Valley; 2. That of the Stone House or Temple-Builders of the table-lands of North America, the Isthmus, and the western coast of South America.

Of these the relationship is obscure, and no certain proof has been furnished of their synchronism or their genetic connection.

(I.) The whites, on their advent, found the east coast of North America covered with dense forests, and inhabited by wild animals and the nomadic Indians. It was only when the wave of migration had reached the basin of the lakes and the valley of the Ohio, and the forest was then cut off, that mounds, earthworks, mines, etc., were brought to light, which prove that this region had for ages been occupied by a numerous, sedentary, and partially civilized people. The date of their occupation of the Mississippi Valley cannot be accurately determined. Their works had been abandoned and overgrown by the forest at least a thousand years—as shown by two generations, living and dead, of mature forest trees which covered them.

These ancient people were agricultural in pursuits, built towns of considerable size, and left such abundant traces as to prove that the population of the region they occupied was as great as the present one.

The degree of advancement in the arts which the relics of the Mound-Builders exhibit is such as to raise them above the condition of absolute savagery, but they were hardly civilized in the present acceptation of the term. Their works were varied in character, and frequently of imposing dimensions, and consisted of fortifications, sepulchral mounds, and extensive structures designed apparently for ceremonial and religious purposes. These are all of earth or rough stone, and there is no evidence of any progress in the mason's art. The buildings were probably of wood, the foundations alone remaining. These people worked the copper-mines of Lake Superior, the oil-wells of Pennsylvania, Ohio and Michigan, the lead-veins of Kentucky, and the mica-mines and steatite-quarries of the Alleghany range; but all this mining in the rock was done by means of stone and wooden implements, and the use of fire; they left no evidence of the possession of other metals than copper, and this was used only in its native state, was never melted, and was fashioned by hammering. They had woven fabrics made with considerable skill from the fibres of plants. Their pottery was generally coarse in material and rude in form, but in some instances was graceful in shape, made of finer clay, and ornamented with incised or painted designs. Their burial ceremonies were apparently elaborate, and cremation was often practiced. Their bones have generally been found decomposed by age; but from such as have been preserved, we may infer that in proportions and form of cranium this race resembled the average Indian, and that they belonged to the great American family of man.

We have as yet no evidence of their possessing domestic animals, and no accurate information in regard to their crops, except that maize was their great staple.

The wide distribution of marine shells throughout the interior of the continent—used for implements or ornaments, of beads, and of mica and copper, soapstone and flint, all from known localities shows that there was considerable internal commerce, but no positive evidence exists of interchanges with foreign nations. The discovery in the mounds of tablets, engraved with symbols or ornaments of a Mexican type, indicates communication with the civilized occupants of the table-lands; but the rarity of these relics and the absence of monuments from a broad space separating their countries, leads to the inference that their intercourse was limited and their relationship not close.

The fate of the Mound-Builders was for the most part extermination by incursions of the more warlike northern nomadic Indians, who had occupied the whole country at the advent of the whites; but it is probable that in the Mandans and Natchez some remnant of the Mound-Builders continued to exist after the occupation of America by Europeans.

(II.) The table-lands of North America, from Salt Lake to the Isthmus, are thickly set with the remains of a civilization much more advanced than that of the Mound-Builders. These are the works of a people at one time far more numerous than at present, though still represented by scattered colonies in our southwestern territories, and found in the occupation of Mexico by Cortez. They were characteristically workers in stone, and have everywhere left monuments of their skill in constructive masonry, which inspire respect and often admiration. The structures raised by this people are mostly communal houses and compactly built towns, but they are often citadels and watch-towers. Many of these are erected with special reference to defence—their exterior walls being unbroken to the height of 15 or 20 feet, and the interior accessible only by ladders. In many instances the towns and houses are located on high and almost inaccessible rocks, evidently with a view to defence. A few of the towns within our own territory, peculiarly well defended by their natural positions, continue to be occupied to the present day—such as the Moqui villages, Acoma, Zuñi, etc.—but most of the area where once a dense population existed has been entirely abandoned. Every available inch of arable land seems to have been cultivated by them, hill-sides terraced, and water for irrigation and drinking brought many miles in canals, and stored in well-built stone cisterns. In the northern provinces of the country inhabited by this people metals seem to have been unknown, and all wood and stonework was accomplished with stone implements.

The modern representatives of these ancient people are peaceful, industrious, ingenious, temperate and moral; they cultivate the soil with great care, and are well clad in softly dressed skins of sheep and deer, or in woolen garments woven by hand, but often very tastefully ornamented and serviceable. They excelled in the manufacture of pottery, which is often graceful in form, and elaborately ornamented with colored designs.

The metropolitan population of Mexico was, however, further advanced in the arts, having well-built and paved towns, good roads, with relay stations for couriers, parks, fountains, courts of justice and police. They also had a written language and picture writing, both on paper, with elementary and professional schools. They employed a number of the metals, gold and silver as ornaments, tin and copper combined to form bronze, which was used for arms and utensils. The structures which they erected were frequently composed of stones of large size, carefully dressed and laid in mortar, with the interiors plastered and painted. The external architectural decoration was frequently exceedingly elaborate and often very tasteful. Their religion was apparently sun-worship, and they frequently offered human sacrifices.

The monuments of Central America and Peru show such resemblance to those of Mexico, that we cannot doubt that the people occupying all these countries must have been in close communication, and intimately related. The monuments of Central America have been described and illustrated by Stevens and Catherwood, Waldeck, Norman, etc., and their number, magnitude and ornamentation have excited great interest and admiration ; but it is believed that only a small portion of these monuments has yet been examined, and that in the dense forests of Honduras and Yucatan there yet remain a large number of towns and individual structures to reward the efforts of future explorers.

In Peru, as in Central America, the population in possession of these countries at the time of the Spanish conquest was the same that had erected the monuments; but in both, as in Mexico, the iron hand of despotism and religious bigotry has nearly exterminated the population, and has destroyed their records, until their characteristics and history are scarcely better known than those of the Egyptians and Assyrians.

The monuments of the Incas and their predecessors in South America are briefly described by the Spanish historians, and have lately been studied by one of our number, Mr. E. G. SQUIER; and their magnitude and interest may be inferred from his statements that the masonry of some of the Peruvian buildings excels anything he has elsewhere seen ; that the great Incarial roads extending from Quito to the frontiers of Chili were constructed with more labor and engineering skill than our Pacific Railroad, and that one fortress guarding a pass in the Andes contains more masonry than all of our coast defences from Maine to Florida. Although exhibiting local differences, the similarities in the remains of the ancient inhabitants of Mexico, Central America and Peru, are such that we are compelled to believe that their civilization was generically the same, and that all these peoples were offshoots from a common stock. The monuments in Central America are often covered with inscriptions, while these are almost wanting in Mexico and Peru ; but both these peoples used paper for writing, and were as little in the habit of making inscriptions on stone as we are, or as most civilized nations of Europe. Therefore the absence of inscriptions cannot be accepted as evidence of inferior enlightenment.

Everything indicates that the civilization of Central America, Mexico and Peru was indigenous, and sprang from a common source, spreading along on the west slope of the Cordilleras from Chili to Central America, and northward to the fortieth parallel. Throughout this region the phases of development were essentially alike, and it is probable that constant intercourse was maintained by sea between South and North America.

The origin of this peculiar civilization is a problem not yet solved, but it is almost certain that it borrowed nothing from Europe, Africa or Asia.

Some facts seem to indicate that it was a growth from seed imported from India by way of the Pacific Islands, many of which contain stone monuments and structures which have a striking resemblance to those of the west coast of America.

Dr. NEWBERRY spoke somewhat fully of his own observations and experiences among the Zuñi villages, at a time when scarcely any Americans had ever before visited them; and also of the peculiar remains of ancient mining operations in the Lake Superior copper-region and in certain of the oil-wells of Pennsylvania and Ohio, as studied by himself. At the close of the lecture he showed a number of very finely-wrought pieces of ornamental weaving obtained among the Pueblo tribes, and a large series of lantern views illustrating the several topics treated of in the course of the lecture.

February 27, 1882.

ANNUAL MEETING.

The President, Dr. NEWBERRY, in the Chair.

Thirty-eight persons present.

The report of the Treasurer, Dr. JOHN H. HINTON, was read.

The principal receipts during the year had been: from initiation fees and annual dues, $1,535.00; from interest on bonds, $152.00; from subscriptions to and sales of the Annals, $335.86; and from contributions to the Patrons' Fund, $100 each from Professor A. R. LEEDS and Mrs. HENRY HERMANN. The chief items of expense had been: $500 for binding portions of the library, and $689.68 for printing and engraving (Annals, circulars, notices of meetings, etc.); for rent of the society's rooms there had been paid, $469.50; and for three U. S. 4 per-cent bonds (to Patrons' Fund), $354.37.

The report of the Recording Secretary, Dr. O. P. HUBBARD, was presented.

Thirty-four sessions of the Academy and eight meetings of the

Council had been held during the year. The papers and communications presented at the meetings had been very varied and valuable. Besides five public lectures, fifty-five formal communications had been made before the Society, which might be classified generally as follows: Archæology, 2; Biology, 3; Chemistry, 4; Geology, 18; Mineralogy, 17; Physics, 11. The average attendance at twenty-four meetings had been forty.

There had been added to the resident membership during the year, twenty-six persons; fourteen had resigned, and two had died—JOHN W. DRAPER, M. D., LL. D., and ALEXANDER L. HOLLEY, E. M.

The Secretary suggested the propriety of further efforts to enlarge the membership of the Academy.

In the absence of the Librarian (Dr. ELSBERG) the President addressed the meeting in reference to the library, reporting the great amount of work that has been done during the past two years, in arranging, cataloguing, and binding the books and pamphlets. The heavy expenses involved in this most necessary and important work have severely taxed the Academy's finances; but as the work is now substantially done, and the chief expenses over, the Society is to be most heartily congratulated in the matter. The great and valuable library is now, for the first time in many years, brought into a satisfactory condition; and having permanent quarters in a positively fireproof building, its security and utility are assured.

Prof. THOMAS EGLESTON reported further in the same strain, in behalf of the Library Committee. He presented to the Society the question of employing a paid librarian, which was referred to the Council; and announced that the arrangements were so far completed in reference to the binding and arranging of the books, that the library would be formally opened for use by June.

The Corresponding Secretary, Dr. A. R. LEEDS, presented his report, relative to the correspondence of the Academy during the year.

Prof. D. S. MARTIN presented the report of the Committee on Publications. The "Annals" of the Academy had been carried on as usual—Nos. 5 and 6, of Volume II, having been issued before the summer adjournment of the Society; and Nos. 7 and 8, which had been unavoidably delayed, being nearly through the press, and very soon to appear. Besides this, a large amount of labor had been expended during the summer and fall of 1881, in the preparation and issue of the Index to Volume I.

The publication of a journal of the Academy's meetings, with the briefer papers and discussions, which had been so long desired and aimed at, had finally been undertaken in the printing of the TRANS-

ACTIONS. This had been accomplished largely by the care and pains taken by Dr. A. A. JULIEN, who had concluded arrangements with the weekly journal, "Science," to publish regular reports of the Academy's proceedings, after which the type could be re-arranged so as to issue the record in a pamphlet form for free distribution to the members. Mr. MICHELS, the editor of "Science," had been very accommodating in the whole matter; and the result was that the TRANSACTIONS could thus be issued at a very moderate cost to the Society. This publication had now been undertaken as an experiment, for one year; and it is hoped that the movement would be so sustained as to assure its permanence.

A change was recommended in the price of the "Annals," from $2 (which rate would be continued to resident members) to $3 for non-residents, and $5 for persons living in the city and not members of the Academy. The TRANSACTIONS are to be sent free of cost to resident members, and furnished to others at the same prices as those just mentioned for the "Annals."

Prof. T. EGLESTON addressed the Society with reference to the approaching Convention to be held at Washington, in regard to the question of organizing the system of International Time, and selecting standard meridians. He recommended that the Academy should take action similar to that of some other scientific bodies, in appointing a delegate to that Convention.

Prof. JOHN K. REES was nominated as such a representative of the Academy, and unanimously elected.

The Society then proceeded to the annual election of officers, with the following result—all being chosen unanimously, save a very few scattering votes:

President,
JOHN S. NEWBERRY.

First Vice-President,
BENJAMIN N. MARTIN.

Second Vice-President,
ALEXIS A. JULIEN.

Recording Secretary,
OLIVER P. HUBBARD.

Corresponding Secretary,
ALBERT R. LEEDS.

Treasurer,
JOHN H. HINTON.

Librarian,
LOUIS ELSBERG.

Council,

DANIEL S. MARTIN,
THOS. EGLESTON,
ALFRED C. POST,
GEORGE N. LAWRENCE,
W. P. TROWBRIDGE,
LOUIS ELSBERG.

Curators,

BERNARD G. AMEND, B. B. CHAMBERLIN,
CHARLES F. COX, HERMAN L. FAIRCHILD,
WM. H. LEGGETT.

Finance Committee,

T. B. CODDINGTON, PHILIP SCHUYLER,
THOMAS BLAND.

THE PRESIDENT elect addressed the meeting, with a brief review of the work and progress of the Academy during several years past, its growth in numbers and in means, the increasing activity of its meetings, and the various grounds for encouragement and congratulation, albeit in the face of many obstacles, and the duty and responsibility of the members, and of all lovers of science and intellectual culture in the community, to sustain and further the interests and aims of the Academy.

Prof. A. R. LEEDS presented the following communication:

DIPHENYLAMINE–ACROLEIN.

Twenty-five grms. of diphenylamine in alcoholic solution were treated with acrolein in excess, and, after standing, the loosely-corked flask was gently warmed for a number of hours, until the smell of acrolein had nearly disappeared. A bulky, dark red precipitate was formed. On boiling with alcohol a deep red solution was obtained, and the portion undissolved formed a tenacious, sticky mass, very awkward to work with. By repeated boiling with water under a return cooler, this mass gradually lost its sticky nature. It was then digested alternately with boiling water and alcohol, until at last the mass became pulverulent, and could be ground up in a mortar. The operation of boiling was then repeated many times, the mass being powdered after each treatment with water, until at length the substance in a state of purity was obtained. Its analysis showed it to be diphenylamine-acrolein, or, as it might be termed, diphenylamine-allylene.

	Found.	Theory.
Carbon	86.26	86.18
Hydrogen	6.29	6.36
Nitrogen	7.28	7.45

It does not melt or sublime, but is decomposed on heating, leaving behind a carbonaceous residue extremely difficult of combustion. It is very slightly soluble in alcohol, insoluble in ether, and readily soluble in chloroform to a dark red liquid. From this solution, and also from that in glacial acid, in which it dissolves to a red liquid, but less readily than in chloroform, it could not be made to crystallize.

Its solution in chloroform was attacked with great energy by bromine. So also its solution in acetic acid, a dark red compound being formed on the addition of two atoms of bromine to one molecule of the diphenylamine. This compound was readily soluble in chloroform, but as it did not separate in a crystalline condition, its analysis was not made. It was probably the addition-compound $(C_{12} H_{10} N)_2 C_3 H_4 Br_2$.

Its solution in acetic acid was attacked by nitric acid, forming a precipitate with a supernatant yellow liquid. Neither the solution nor the precipitate yielded a crystallizable nitro-product, and their study was abandoned.

March 6, 1882.

REGULAR BUSINESS MEETING.

The President, Dr. J. S. NEWBERRY, in the Chair.

Thirty-five persons present.

The report of the Council was read, recommending for election, as Resident Members, the following named persons, previously nominated in due form:

FREDERICK W. DEVOE, WILLIAM E. GAVIT,
E. AUSTIN OOTHOUT, DAVID ROUSSEAU,
FERD. J. G. WIECHMANN.

They were all elected by unanimous consent.

The PRESIDENT showed a specimen, brought by Miss F. R. M. HITCHCOCK, of the peculiar blue-paper-like corn bread, used by the Zuñi people, and referred to in his lecture of February 20th.

Mr. GEORGE F. KUNZ exhibited a unique specimen of asteriated blue sapphire, from Ceylon, from the cabinet of the late Mr. MACMARTIN of this city. The specimen is a perfect hexagonal pyramid, about two inches long, and an inch wide across the base, which latter is polished and displays a very beautiful asterism The color is a fine blue, though not transparent. Also a pink-tinted apophyllite, from the new tunnel through the Bergen Hill.

Mr. NELSON H. DARTON then read the following paper:

NOTES ON THE WEEHAWKEN TUNNEL.

(Abstract.)

The railroad tunnel now being cut through the trap of Bergen Hill, near Weehawken, has excited considerable attention among the mineralogists and others in this vicinity, on account of the following minerals:

Calc Spar. This in its first form is very abundant, in quite pure and perfect crystals, often with a fine yellow tinge, but seldom transparent: the variety known as dog-tooth spar has been found in excellent condition, but only in limited quantity.

It seems peculiar to this mineral here to occur in vertical veins in the trap, while most of the other species occur in beds more or less horizontal: thus showing most of the calcite here to have crystallized from inflowing water, filling up the fissures produced by various causes. Very little of it was found in cavities in the trap, as this does not seem to be amygdaloidal here. A few almost perfect geodes and druses of so called nailhead spar have been observed, mixed with the dog-tooth spar.

Datholite has been found mostly as druses or small crystals, which were very plentiful, sometimes as large crystals, weighing from three to six grains, and in good-sized groups. I noticed that the larger the crystals were, the more vitreous their lustre and the less their transparency. They generally occur in vertical veins, at right angles to those of the calcite; when they occur in geodes, they are generally in cavities in the trap. This place is a new locality for *Hayesine*, which has, so far as I know, never been observed in any other place than in South America, and there mixed with gypsum and alum. About half a grain was secured here by scraping the cavity. On chemical examination it was found to be a borate of lime, containing but a mere trace of silica (derived probably from the scrapings of the cavity), *i. e.* Hayesine. The analysis used up nearly all obtained of this interesting mineral, and I am now eagerly seeking for more to verify my results.

Thomsonite has been reported at Bergen Hill, but I have never observed it.

Pectolite. Most of this species found here is a stellated variety, in which the fibers diverge at a greater angle than 45°. The fibers are rarely over two inches long. Masses weighing as high as three and even four pounds have been frequently found, and more or less is taken out every day, sometimes in beautifully perfect specimens,

Analcite. A few specimens have been obtained in fair sized crystals, occurring with dog-tooth spar; but it is far from being abundant.

Apophyllite has been quite abundant, generally in white crystals, more or less perfect—occasionally pink. In one case, a pocket was met with, containing, besides some white and pink apophyllite, a little of a pure purple tint. It seldom occurs alone, but usually with calcite, datholite and stellar pectolite.

Prehnite is quite abundant in traces, never in large crystals, contrary to the conditions in the Pennsylvania railroad cut. It generally occurs in small cavities, and sometimes with calcite in some of the veins.

Sphene is met with in very small quantities, disseminated through the harder trap.

Stilbite. But little stilbite has been found, and that descending from some fissures into the natrolite.

Natrolite. This has been remarkably abundant. It has been found in groups of every shape, and in various sized crystals, sometimes in nearly perfect globes fully two inches in diameter, with druses, geodes, and other forms of great beauty and perfection. Most of it has been taken out in plates, four or five inches square, and about five-eighths inch thick, coming from a bed spread over a large distance.

This has an average thickness of one-half inch, and is thrice intercepted by two inch veins of calc spar, running vertically.

Heulandite. Small crystals of this species are said to have been found in some cavities.

Laumontite. Some small weathered specimens of this were found in the trap, and it was also noticed quite plentifully in traces.

Chabazite has been quite rare, a few poorly formed crystals having been found on some of the masses of apophyllite ; also two excellent crystals of a pure yellow tinge, and quite transparent.

Pyrite. This species is very abundant, profusely scattered through the trap, mostly in masses, but often in excellent crystals drused on the trap.

Chlorite (?) is quite abundant, in masses and large imitation crystals, weighing five or six pounds ; most of it occurs in a vein about six feet wide, within a few feet east of the pyrite locality. It is of a very dark color, quite impure and brittle, and was mistaken for coal by some parties visiting this shaft, who spread the report that a bed of coal eight feet wide had been discovered.

In closing, Mr. DARTON expressed his belief that much more fine material would still be found in excavating the space between shafts numbers one and two.

The paper was illustrated with sections of the tunnel, and by many choice specimens of the minerals described.

DISCUSSION.

Mr. CHAMBERLIN, Mr. G. F. KUNZ, and Prof. D. S. MARTIN, made remarks on the paper, expressing much interest in the variety and beauty of the minerals found in this tunnel, and making comparisons with the modes of occurrence of like species in the other Bergen tunnels.

Mr. WM. EARL HIDDEN, then read the following paper:—

A PHENOMENAL FIND OF FLUID-BEARING QUARTZ CRYSTALS.

In a paper read before this Academy in January last, on the emeralds from Alexander County, North Carolina, mention was made of certain remarkable crystals of quartz found associated with them.

These quartz crystals having shown various peculiarities rarely observed, I have thought the recounting of these phenomena would perhaps be of interest.

Crystals of quartz containing inclusions of fluids and gases are not uncommon, though crystals having such inclusions plainly visible to the naked eye are rarely found.

The quartz crystals from Western North Carolina have attained a wide celebrity from the fact of their inclusions being of remarkable size. In some cases they were wholly unprecedented.

Mr. George W. Hawes, in an exhaustive paper upon the liquid inclusions in quartz (Am. Jour. Sci., March, 1881), mentions Branchville, Conn., as furnishing massive quartz containing a greater number of included cavities than had before been observed, of which he gave a very thorough and valuable description. He also mentions, as noteworthy, cavities two mm. in diameter, from Fibia, St. Gothard, and those of 5 mm. in diameter, from Pike's Peak, Colorado. From Herkimer county, N. Y., I have seen crystals having inclusions of even 10 mm. in their longest diameter, though such crystals were of great rarity.

Before recounting the size of the remarkable inclusions in the North Carolina crystals, it might be well to describe the position of the "pocket" in question, and its relation to the rock in which it occurred.

It was while prospecting for new veins bearing emeralds, that this pocket was unexpectedly discovered. A narrow drift of quartz fragments, with small flakes of mica, was the only exterior sign noticeable. At the head of this drift, a shaft was located and sunk to a depth of nineteen feet, with the following interesting results.

The drift, within a foot of the surface, took shape as a solid vein of quartz, which rapidly widened until, at six feet depth, it had attained a width of fully three feet. Within the next two feet, the pocket nature of the vein had become apparent, by the presence of hard lumps of red clay, within which small crystals of quartz were found.

The vein for the next foot was almost entirely composed of this hard red clay. Then, to our great astonishment, one of the miners, striking his pick very forcibly, saw it disappear wholly from his sight. Naturally he was alarmed. We all thought for a time the safest place was at the top of the shaft. Feeling from past experiences, at the locality, that a cavity of not very unusual dimensions was about to be opened to our view, we descended and resumed the work.

Procuring a long stick, I probed this cavity, so as to arrive at its size; this being a necessary precaution to work it out properly and safely.

It was thus shown that the pocket was about three feet wide, seven feet long, and at that time about three feet deep, though I could push the stick quite deeply into the clay at the bottom.

Exposing at full length the upper part of the cavity, it showed all along its sides and at the bottom stalactitic and stalagmitic forms of red mud.

The quartz, which at one time had completely lined the pocket, had, by process of disintegration, dropped into the open space below. It was in the mud and clay in the bottom of the pocket that all the crystals subsequently found were discovered. Only at the very bottom were the walls found "in situ." This pocket differed in no respect from those commonly occurring in this region. They are all shrinkage fissures, situated in a counter direction to the strata, of very limited extent, and nearly perpendicular in position. The country rock is gneiss, trending N. N. W. and S. S. E., with a dip nearly vertical. A thick layer of soil everywhere mantles and conceals it from view. Three days of careful work, by our most trustworthy and painstaking miner, were spent in exhausting this pocket.

No mineralogist could have been more careful in preserving the angles and edges of the crystals than was this miner. Not one crystal of the hundreds taken out was in any way injured.

Over four hundred pounds of *choice* quartz crystals were obtained from this one pocket, besides the nine emeralds previously spoken of and exhibited before this Academy. Of good, bad, and indifferent, there was found in all nearly half a ton.

It was noticed that all the crystals that had been directly attached to the walls were semi-transparent and without any great development of the prismatic faces; while, implanted upon them, were crystals of great beauty and transparency, varying from citrine-yellow to dark chocolate-brown in color, and for the most part perfect in form. Two-thirds of them were perfectly terminated at both extremities and with considerable prismatic development. It was these latter that contained the fluid-inclusions.

Large plates of rosetted mica were quite common, and on them were implanted small crystals of rutile and of quartz, in rare perfection. It is to these smoky crystals, found in this pocket, that I now ask your attention. When the smoky crystals were first found, they were noticed to contain many cavities seemingly filled with a very clear and lustrous fluid. Though no bubbles of air (or gas) were observed to move in these cavities at that time, yet I knew these crystals to be the so-called "water crystals" of mineralogists.

I take pleasure in recording the remarkable size and quantity of the cavities enclosed in these crystals. The longest cavity noticed was nearly *two and one half inches long* and one quarter of an inch wide. Cavities of one inch were not uncommon, while those of one quarter inch and less were, in truth, without number.

Many of the crystals seemed to be made up almost wholly of cavities, whose walls were barely thick enough to keep them separated. Many hundred, plainly visible to the unaided eye, could have been counted in a single crystal.

For some time after these crystals were removed from the pocket, no bubbles were noticed in any of the cavities. Some peculiar condition of the crystal, or of the atmosphere, then existing, probably prevented their formation. Later, the bubbles appeared in great numbers. A few of the crystals were, as water-bearing crystals, very remarkable in size. One weighed nearly twenty-five pounds, had both ends terminated, was of a dark brown color, and as beautiful as any we have seen from other localities. All the water-bearing crystals were large, none less than two inches in diameter and many of over three pounds in weight. The cavities were arranged parallel to each other and to either a rhombohedral or a prismatic face.

The interesting phenomena I observed in these crystals did not occur until some time after their discovery. The best crystals of the "find" were carefully selected and placed where they were considered to be safe—safe at least from molestation. That the weather would interfere, or in any way affect them, did not enter my mind.

One evening in November last (the "find" occurred on Oct. 24), I left these crystals nicely arranged at the mine, except a few of the smaller ones, which I carried to my log-cabin home, thinking the while of what a treat I had in store for mineral collectors and for science. I will frankly confess that I was inordinately proud of my "find"—verily, "pride goeth before destruction."

Now, it is of the *destruction* of these crystals that I must speak. During the night following, the mercury unexpectedly descended below the freezing point. About midnight I was awakened by several sharp reports, like the explosion of gun caps. Over a dozen of these explosions occurred.

In the morning the family were curious as to the cause of the strange explosions heard in the night. Upon the table, where the crystals had been placed the evening before, there remained now only some few sharp fragments of quartz. Pieces of the crystals, large and small, were found even fifteen feet away. In fact they were completely ruined and now possessed only the interest of reminding one of what had been. The cold had caused the water in the cavities to freeze, and consequently to expand, and then burst the crystals.

I returned to the mine with the gravest fears for the safety of the finer crystals left there. Judge of my dismay to find not one of them, even the smallest, left intact.

Crystals, that only a few hours before were rare examples of the workings of Nature's laws, were now, by these same mysterious laws, left only as an evidence of her power to do and to undo her grandest achievements. Only crumbled masses of fragments remained to tell the story.

Those with few cavities had burst, scattering large fragments, widely separated; while those containing minute cavities lay as a heap of small fragments frozen together, *in a coherent mass.* This last feature, while being a sad reminder in one respect, is of value to science, since it shows conclusively the abundance of the fluid included; and also, what is of more importance, that this cementing ice was formed either directly from the fluids *in the crystals*, or by influences which they exerted. I do not believe this cementing ice was wholly formed by the freezing of the water contained in the cavities, but was gathered there by the attractive influence of the liquid carbon di-oxide upon being so suddenly set free; that this liquid carbon di-oxide did, by its natural affinity for moisture, create around it an atmosphere so cold that even the little dampness then existing in the air was congealed upon the crystal fragments.

As the room was a dark one, I had all these masses and larger fragments carried out and placed in the sunlight, for no other reason than to examine them more carefully. I did not anticipate from this any further developments of scientific interest. Again, believe my astonishment, as soon as the rays of the sun touched them, to notice an ebullition commence at once, which, strangely, could be heard a few feet away.

I noticed in some of these masses a very distinct odor of sulphuretted hydrogen, which was quite fugitive in some of the pieces, while constant in others. This ebullition was continued for over an hour, growing less as thawing progressed.

While holding a mass of frozen fragments, my hand would become quite wet with the melting ice. I am not in error in stating that a cub. cm. of this fluid could have been easily saved, had the proper means been at hand. It is much to be regretted that none was preserved.

Mr. A. W. WRIGHT, in a paper following that of Mr. HAWES, already referred to, gave some valuable data in regard to the composition of fluid-inclusions in quartz. The following is a summary of his results:

He found "that smoky quartz, on heating, entirely lost its color, and that this color was due to the presence of a hydrocarbon of the nature of bitumen."

Aside from this bituminous matter, which is not known to be specially connected with the cavities in the quartz, he obtains the following analysis:

Carbon di-oxide	98.33
Nitrogen	1.67

with traces of sulphuret ed hydrogen, sulphuric acid, ammonia, fluorine and probably chlorine.

The results of his investigations showed that the contents of these cavities are chiefly water and carbon di-oxide, with a small proportion of nitrogen.

I noticed some curious phenomena in a single fragment, which had by some means escaped destruction by freezing.

This specimen had several small cavities, arranged nearly parallel to each other. At temperatures below 70° a small bubble could be plainly seen to move in each cavity, as the position of the specimen was changed. It was further noticed that the cavities contained two liquids, in one of which the bubble was wholly confined in its movements. This was seen to be the central and more transparent fluid.

If this specimen was slightly heated (the mere heat of the hand was found sufficient), the bubbles would grow gradually less until they disappeared entirely, and the fluids would unite.

On cooling, a critical temperature would be reached, when all the cavities would be filled with numberless minute bubbles, which, rushing together, would in a few seconds form to its full size the bubble originally noticed. I found that this experiment could be repeated indefinitely, without any diminution of its interesting phenomena or risk of damage to the specimen.

To Alexander county, North Carolina, and to many of the surrounding counties, we can hereafter look to produce fluid-bearing quartz crystals second in interest to those of no other region in the world.

[Mr. HIDDEN'S communication was illustrated with a very striking series of inclusion crystals, and of the fragments split off by the frost from the large crystals, as described. The pieces were in the form of large flakes or plates, parallel to the faces of the rhombohedron, and were clouded and filled with elongated or rod-shaped cavities, in immense numbers and of conspicuous size.]

March 13, 1882.

SECTION OF CHEMISTRY.

The President, Dr. J. S. NEWBERRY, in the Chair.

Thirty persons present.

Prof. D. S. MARTIN, in behalf of Mr. KUNZ, exhibited a series of crystals of Diopside, from the town of DeKalb, St. Lawrence Co., N. Y. This variety of pyroxene has never before been discovered, it is believed, in this country, though long known from the two localities of Ala and Traversella, in Piedmont. Its occurrence here is therefore, a matter of much interest; and the beauty and transparency of the crystals, and their perfection of form, render them quite remarkable.

Mr. ARTHUR H. ELLIOTT then read the following paper, which was largely illustrated with specimens of the various forms of apparatus described, and by experiments:

THE METHODS OF ASCERTAINING THE SAFETY OF KEROSENE OIL.

Before speaking of the various methods that have been proposed, and are now in use, for ascertaining the safety of kerosene oil, it will perhaps be well to look over the conditions of the problem. As we all know, kerosene oil is the product of the distillation of crude petroleum. This crude petroleum is made up of a number of oily liquids having different boiling points—in other words, liquids that give off vapors at different temperatures. These temperatures vary from 65° to 400° or 500° F. From 100 parts of crude petroleum there is obtained by distillation, in round numbers:

Benzine, Naphtha, etc.,	15–16 parts.
Kerosene Oil,	55 parts.
Paraffine, Lubricating Oils, etc.,	30 "

It will thus be seen that only about half the crude petroleum is fit for burning. For the benzine, naphtha, etc., are too volatile and dangerous, while the paraffine is only fit for lubricating, being too thick to flow through an ordinary lamp-wick. On account of these two facts, the kerosene oil is the most valuable product of the distillation of crude petroleum, and brings the best price in the market. Benzine is worth only half as much as kerosene oil, while naphtha and paraffine bring only one-third as much.

From these circumstances it follows that in distilling crude petroleum, the oil-refiner tries to get as much kerosene oil in his product as possible. To increase the quantity of kerosene oil given by the petroleum under treatment, the refiner may do one or both of two things. He may collect as kerosene those products which boil at either a lower or a higher temperature than good kerosene. The latter action is not so important as the former. In the last case an oil is obtained that is too thick and heavy to burn in ordinary lamps, and does not give a brilliant light. But in collecting the naphthas, which boil at a lower temperature than good kerosene, several very important results are produced. Besides adding to the quantity of kerosene in the products, these low boiling oils increase very much the brilliancy of the light given by the kerosene. Here let me state exactly what I mean by this expression. I do not mean to say that the amount of light obtainable from a given quantity of low-boiling oil is greater than that obtained from a higher-boiling oil; but that the intensity of the light given by the low-boiling oil is greater than that given by the high-boiling oil. When these low-boiling oils are allowed to mix with the kerosene, it will be seen that they give brilliancy to the light, besides adding to the quantity of product obtainable from a given crude petroleum. This is the commercial side of the question. Now let us look at it from another standpoint—that of the consumer. These low boiling-oils give off vapors, and these vapors, when mixed even in a small proportion with air, form explosive mixtures. Then comes the problem to be solved in ascertaining the safety of kerosene oil. At what temperature does a given sample of oil give off inflammable vapors? And at what temperature must such a sample *not* give off these vapors? The latter question has already been determined and varies in different States of the Union; some consider 100° F. as sufficiently high; others require that the oil shall not give off inflammable vapors below 140° F. These temperatures have been fixed upon after experiments made with burning lamps, the details of which I will not trouble you with. Having decided at what temperature an oil shall not give off an inflammable vapor, it becomes necessary to fix the conditions under which the oil shall be tested, to determine whether it is or is not giving off this inflammable vapor. For this purpose, quite a number of pieces of apparatus have been devised; and in experimenting with these, I have reached some results that may prove not uninteresting.

The various forms of apparatus used in testing kerosene for inflammability, and the presence of inflammable vapors, may be divided into two classes: first, those in which the safety of the oil is determined in an indirect manner; and, secondly, those where the direct ignition of the vapors evolved is resorted to.

In the first class, we have the apparatus of Salleron and Urbain, of Paris; where an attempt is made to determine the presence of inflammable vapors by finding the tension of the vapor of the oil at any given temperature, the idea being that the oil containing naphtha, benzine, and the low-boiling oils, will give a vapor-tension greater than an oil without these lower products. But, unfortunately, the apparatus devised for this purpose does not give reliable results, and is of little value.

Another experimenter has sought to determine the safety of kerosene by obtaining the index of refraction of light, when transmitted through a given sample of oil. But experiments have proved that there is no direct relation between these indices and the quantity of low-boiling oil present in a sample of kerosene; indeed, the results are utterly valueless in the question of safety.

The second class of apparatus, in which a direct ignition of the vapors is obtained, may be again divided into, first, those where the oil-surface is exposed, and called "open testers," and, secondly, those where the oil-surface is more or less covered, and called "closed testers."

Of these two divisions, the open testers are the first that were made and used. About twenty years ago Tagliabue devised his open petroleum-tester. It is a very simple affair, and consists essentially of a glass cup to hold the oil, which fits into a vessel of water that can be heated slowly. Having filled the glass cup with oil, a thermometer is hung in it and the whole is placed in the vessel of water; the latter is heated, and a small flame is constantly brought near the oil until a blue flash passes over the whole surface; the thermometer is now noted, and the temperature at which the blue flash appears is called the "flashing point" of the oil.

There are many details that affect the "flashing point" of an oil on this apparatus. Among these, I would mention the fact that rapid heating of the oil will lower the "flashing point," and also that the quantity of oil in the cup and the distance of the ignition-flame from the oil-surface cause the same result.

While experimenting with this apparatus, I have noted a phenomenon which has a bearing upon the safety of kerosene oil. If the apparatus is used in a very quiet room with no air currents, on approaching the oil-surface with a flame from time to time, it will be noted that, as the oil becomes heated, a temperature is attained at which the flame used for ignition becomes perceptibly larger and has a bluish outer envelope, which is very distinctly seen. This bluish exterior of the ignition-flame is very characteristic, and is noted many degrees below the flashing point of the oil in this apparatus. A very little thought will show what this phenomenon means. It will be observed that this blue extension of the flame becomes more and more marked until the oil "flashes." It thus appears that, as soon as the flame begins to enlarge, the oil is giving off inflammable vapors, but not in sufficient quantity to produce a "flash" on the surface. The vapors given off before the oil "flashes" are so light and easily diffusible that they are lost before they can form an explosive mixture with the air, for the flash is nothing more or less than a miniature explosion upon the oil-surface. Not until the vapors become so dense that they cannot diffuse rapidly, will the oil flash. The importance of this fact will be apparent later in this paper.

In testing oil with open testers, efforts have been made to produce uniform results by filling the oil-cup always to the same level, and also by various devices to obtain an ignition-flame of a given size and at a given distance from the oil surface. The ignition-flame has been replaced by the electric spark, as in the apparatus of SAYBOLT; but neither this, nor any mechanical arrangement of flame, can overcome the difficulty of losing the lighter vapors in the open apparatus.

We will now discuss the question of "closed testers." In these an effort has been made, with more or less success, to prevent the escape of the lighter vapors lost in the open apparatus. Tagliabue, who made the first "open tester," has also devised a closed apparatus. In this he has simply placed a heavy brass cover, with a system of valves and a little chimney for igniting the vapors in, upon his open tester. The apparatus is not much better than an open tester, and has many drawbacks. First, it is extremely difficult to clean, since the valve-system below the cover dips into the oil, and it is impossible to clean the apparatus after using it with one sample of oil, and before using it with another. Secondly, the results obtained with this apparatus are but slightly lower than those obtained with a good open tester. In using the closed tester of Tagliabue it was noted that the enlargement of the flame took place at almost the same temperatures as in the open testers, the oil not flashing till many degrees above this point, a proof positive that this apparatus does not prevent the escape of the lighter vapors of kerosene. This last fact is partly due to the lack of space beneath the cover of the tester and the oil surface.

Fully realizing the importance of this whole subject, the English government appointed a commission to report upon the question; and the result of this report was an apparatus devised by Prof. ABEL, the chemist to Woolwich Arsenal. Prof. ABEL insures the slow heating of the oil by using a large quantity of water and by using an intermediate air-space between the water-bath and the oil-cup. The oil-cup has a point to be used as a filling-gauge, and is fitted with a tight cover, which carries the flame for ignition of the vapors. This apparatus certainly prevents the escape of the lighter vapors, but unfortunately the ignition lamp which is attached to the cover permanently, and is made of gun-metal, becomes very hot, and by communicating its heat to the cover raises the temperature of the oil at the sides and surface, and produces results that are too low; *i. e.*, this apparatus gives "flashing point" much lower than any other I have used, except MANN'S apparatus, which I shall speak of later.

A very ingenious type of "closed tester" is that devised by BERNSTEIN. This consists of a tube in the form of a letter U, which contains the oil to be tested. One limb of this tube is enlarged, and in it is fitted a cap containing two wicks, one central and the other at the side. Around the central wick is a tube communicating with the enlarged limb of the tube below, and the rest of the cap is closed. To operate this apparatus, the limbs of the tube are filled with water to the level of the bottom of the larger end; into the larger end a measured quantity of the oil to be tested is introduced, the cap with the wicks is fitted, and the whole is placed in a vessel of water of the temperature at which the oil should *not* flash. When this temperature is nearly reached, the little wick on the side of the cap is lighted ; and when the thermometer reaches the standard temperature, a measured quantity of water is poured into the narrow limb of the U tube. By this action the level of the oil in the enlarged portion of the tube is raised, and any vapors that may be there are forced through the tubes around the central jet. These vapors meet the flame of the jet already lighted, they become ignited, and by so doing ignite the central wick.

It will be seen that as soon as the oil-level is raised, it is not easy to repeat the experiment ; hence the apparatus is only intended to determine at what temperature an oil does *not* give off vapors, and not to determine its flashing point. One important difficulty in this apparatus is the fact that the central wick will not ignite with certainty every time that an oil is giving off inflammable vapors. For I have repeatedly failed to ignite the central wick in an experiment, and on removing the cap have immediately obtained a flash with the oil in the cup. When the central wick ignites, this apparatus gives results that are generally higher than with open testers, which may be due to the fact that the vapors must have a certain density before their ignition will inflame the central jet.

One of the best of the recently devised forms of "closed testers" is that used in the State of Wisconsin. Its construction is very simple, but it embodies some features that make it stand before those I have already mentioned. It consists of a copper water-bath, a copper oil vessel, and a cover with two holes in it, through one of which passes a thermometer.

The oil-cup holds a good quantity of oil, and there is considerable space above the oil-surface for the accumulation of the vapors. Its use is very simple, and consists in heating the oil slowly by means of the water, the flash being obtained by introducing a small flame into the second hole of the cover. The apparatus is not costly ; it is easily used and cleaned, and the results obtained are quite near the truth.

Some years ago Mr. MANN conceived the idea that the best way to test oil is under the same conditions that obtain in using it. For this purpose he devised a metallic lamp, about the same size as an ordinary kerosene one ; he replaced the usual wick-holder by a tube, which could be loosely closed with a plug. The side of the lamp contained a valve opening inwards, through which a flame could be introduced to ignite the vapors. The thermometer was placed in a closed tube fitted into the side of the lamp. This lamp was placed in a water-bath that fitted it, and the whole heated slowly. A small flame (a gas-jet) was introduced from time to time, until the plug was driven out by the force of the explosion of the mixture of vapors and air within.

At first sight this appears to be the acme of oil-toilers; but, alas, it has several important faults. It is not a matter of indifference how the plug is placed in the tube. If it is too tight, it will not be ejected by the explosion, and the flame will force itself out at the side valve. It is also important that the instant of right admixture of vapors and air should be the instant that the flame is introduced. For if the air contains more vapors than will form an explosive mixture, simple combustion at the valve, and not explosion, is the result. By introducing the electric spark as a means of ignition, the difficulty of admixture may be overcome; but the force necessary to eject the plug must always be a difficulty.

In this paper I have not been able to discuss all the various apparatus used for testing kerosene oil; but I have taken some of those most used, and that are types of others.

Yet one other apparatus remains to be noticed, and this is the "electric closed tester," devised by Mr. PEASE, of Buffalo. In this apparatus we have the usual oil-cup and water-bath. But the oil-cup has a cover, and an overflow tube to insure the level of the oil remaining the same during the process of heating; since the heating causes expansion of the oil and thus raises the level. Into the cover of this tester are fitted two wires, between which a spark from an induction-coil may be passed. The usual outfit of thermometers completes the apparatus.

This apparatus is very nicely made, and the overflow-tube is an important device, especially with the heavier oils. But, in working with this tester, I was surprised to obtain results very little better than with an open tester. This is due to the fact that the spark-wires are in the centre of an opening in the cover, and that this opening is so large that the vapors escape around the sides without being ignited. To prove this, I covered the opening with a small piece of glass, and obtained a flash at a much lower temperature, because the vapors could not escape.

For the sake of comparison, I have tabulated the results obtained with the various apparatus, and the quantities of oil used in each.

	Oil Used.	Flash.
Tagliabue's (open)	2 ounces	97° Fah.
Saybolt's (open)	2⅓ "	99 "
Tagliabue's (closed)	3 "	93 "
Abel's (closed)	2½ "	76 "
Bernstein's (closed)	1¾ "	100 "
Wisconsin (closed)	5 "	86 "
Mann's (closed)	10 "	75 "

Looking at the above table, and rejecting the results from the apparatus of both BERNSTEIN and ABEL, which are faulty in construction, the following conclusions may be drawn:

1. Open testers are not to be recommended, since the light vapors are lost.

2. Closed testers should be so constructed as to prevent the loss of vapors, and to give conditions that obtain in burning an ordinary kerosene lamp. This last fact is important in connection with the quantity of oil used. A glance at the table reveals the fact, that the greater the quantity of oil in the apparatus, the lower the "flashing-point." It is ridiculous to make a test on two ounces of oil, which is used in a lamp holding twelve or more ounces. The test should be made upon at least ten ounces of oil, and in an apparatus where the personal equation of the operator shall have little or no influence.

The paper of Mr. ELLIOTT was discussed at some length by Prof. SEELEY, Dr. NEWBERRY and Mr. WOLCOTT.

March 20, 1882.

LECTURE EVENING.

The President, Dr. J. S. NEWBERRY, in the Chair.

The larger hall was entirely filled.

Ordinary business of detail was omitted; and the regular lecture of the monthly course was delivered by Prof. JOHN K. REES, on the subject of—

SOME RESULTS OF PHOTOGRAPHY AS APPLIED TO ASTRONOMY.

(Abstract.)

We find Mr. NORMAN LOCKYER, of England, stating in his book on "Star-gazing," that "celestial photography was founded in the year 1850 by Prof. BOND of Cambridge, Mass., who obtained daguerreotypes of the moon at about that date." This appears to be an error. Dr. HENRY DRAPER, of this city, in a paper published by the Smithsonian Institution, tells us that the first photographic representations of the moon ever made, were taken by his father, the late Prof. JOHN W. DRAPER. Prof. DRAPER presented his specimens to the New York Lyceum of Natural History. In the minutes of that body we find the following memorandum:—

MARCH 23, 1840.—Dr. DRAPER announced that he had succeeded in getting a representation of the moon's surface by the daguerreotype. The time occupied was *twenty minutes*, and the size of the figure about one inch in diameter. DAGUERRE had attempted the same thing, but did not succeed. This is the first time that anything like a distinct representation of the moon's surface has been obtained.

(Signed) ROBT. H. BROWNNE, *Secretary.*

Since that time celestial photography has been immensely improved. When we read the names of the men who have done the most to develop this beautiful branch of investigation, we find that a member of the New York Academy of Sciences stands at the head.

To LEWIS M. RUTHERFORD the world of science owes a great debt for his untiring perseverance and ingenuity, shown in developing Celestial Photography to such a point that it now bids fair to replace, in a great measure, all other methods of observation.

[The general outlines of the method of photography were given, the several obstacles to be overcome were mentioned, and the plate-holder illustrated and explained. The necessity of having a good clock was shown. The differences between reflectors and refractors for photographic work were illustrated, several advantages of each kind of instrument being mentioned.]

As a piece of interesting history relating to our subject, let me quote from an English work, Chambers' Descriptive Astronomy.

"To an American we are indebted for the best pictures of our satellite yet produced, and it is difficult to conceive that anything superior can ever be obtained; and yet with the fact before us that De la Rue's are better than anything taken in this country, so it may prove that even the marvellous pictures of Mr. RUTHERFORD may be surpassed."

Mr. RUTHERFORD appears, from a paper in SILLIMAN'S *American Journal of Science* for May, 1865, to have begun his work in lunar photography in 1858, with an equatorial of 11¼ inches aperture and fourteen feet focal length, and corrected in the usual way for the visual focus only. The actinic focus was found to be $\frac{7}{10}$ of an inch from the visual. The instrument gave pictures of the moon, and of stars down to the fifth magnitude, satisfactorily, when compared with what had been done previously, but not sufficiently so to satisfy Mr. RUTHERFORD. After trying to correct for the photographic rays by working with combinations of lenses inserted in the tube between the object and the sensitive plate, he commenced some experiments, in 1861, with a silvered mirror of 13″ diameter. This was mounted in a frame and strapped to the tube of the refractor. Mr. RUTHERFORD enumerates several objections to the reflector for this kind of work, but admits the advantage of coincidence of foci. The reflector was abandoned for a refractor, specially constructed, of the same size as the first one and of nearly the same focal length—about $\frac{1}{10}$ shorter. This instrument was corrected for the chemical rays only, and was, therefore, worthless for seeing. The glass was completed in December, 1864; but it was not until March 6 of the following year that a sufficiently clear atmosphere occurred, and on that night the negatives were obtained, from which the pictures of the moon that we shall see to-night were taken.

But even with this method Mr. RUTHERFORD was not satisfied. Coming back to the 11¼-inch object glass which he had used at first, he determined to see whether or not the addition of a meniscus lens, outside the front lens, would not give him the requisite shortness of focus and bring the actinic rays absolutely together. By this arrangement he got a telescope which can be used for all purposes of astronomical research, and he has also eclipsed all his former efforts.—(*Lockyer, Star-gazer*, p. 467.)

In the series of moon-pictures by RUTHERFORD and DRAPER, we have a complete map of the moon; not only are the grander outlines clearly shown, but many of the smaller details. [Illustrations were given of the work of BEER and MAEDLER, of Germany, and SCHMIDT, of Athens. Comparisons were made between the photographs and eye-drawings, and the use of photography in detecting changes in the moon was alluded to.]

In taking sun-photographs, it becomes necessary, on account of the dazzling brightness of the sun's light, to make the exposure practically instantaneous. Some astronomers reduce the aperture of their telescopes, by suitable diaphragms, to about two inches diameter, thus cutting off a great deal of the sun's light. Even then, the time of exposure is less than the three hundredth part of a second. [The method of making these quick exposures by what is called the instantaneous slide was explained. A series of pictures of the sun, by MR. RUTHERFORD, was then thrown on the screen. The use of photography, in studying the mottled surface of the sun, was illustrated by photographs from RUTHERFORD and JANSSEN, and drawings from NESMITH, SECCHI, HUGGINS and LANGLEY.]

There are times when the sun shows us surroundings which it is impossible to see ordinarily, as at total solar eclipses. Such a time is an exciting moment, the eclipse lasting from a few seconds to some six or eight minutes only, and the average time being such that altogether we have only a few days in a century for observation. Drawings made by two observers, side by side, differ very peculiarly. Photography assists us immensely in our study, and some of the best observations of eclipses have thus been made. [Illustrations of the photographs of 1851, 1860, 1869, 1870 and 1872 were then thrown on the screen and explained. A full description was given of the apparatus used by the American parties, in photographing the transit of Venus, and some illustrations of actual photographs taken were shown.]

But not only are we able, by the aid of photography, to study the members of the solar system, but it is possible thus to investigate the relations of the immensely far-off stars, and even to determine their distances.

In the heavens we discover with a telescope that many stars are changing their positions and distances with respect to their near visible companions; and investigations have been made proving that some of these revolve about the others as centres, forming systems of their own, like our solar system.

The measurements required for this work are numerous and delicate, and can be made only on nights when the seeing is very fine, by a skillful observer. Mr. RUTHERFORD has adopted a method of photographing a cluster of stars, or a double star, in such a way, that the plates can be laid away and measured by a person simply trained in the use of a micrometer. These plates may be taken at large intervals. On comparing the measurements, a decision can be reached as to whether any stars have moved with respect to the others.

Let me describe Mr. RUTHERFORD'S method:

First, a wet plate is exposed for four minutes. This gives stars down to the tenth magnitude. But there may be points on the plate which are not stars; hence a second impression is taken on the same plate, after it has been slightly moved. All points now doubled are true stars. Now for measures of arc. After this second photograph is taken, the clock is stopped. The now moving stars down to the fourth magnitude are bright enough to leave a continuous line; the length of this, in a very accurately known interval, say two minutes, enables the arc to be calculated. Next comes the mapping. The negative is fixed on a horizontal divided circle on glass, illuminated from below. Above it is a system of two rails, along which travels a carrier with two microscopes, magnifying fifty diameters. By the one in the centre, with two cross-wires in the field of view, the photograph is observed. By the other, armed with a wire micrometer, a divided scale, on glass, which is fixed along the rail, is read. Suppose we wish to measure the distance between two stars on the plate. The plate is rotated so that the line which joins them coincides with that which is described by the optical axis of the central microscope (marked by the cross-wires), when the carrier runs along the rails. This microscope is then brought successively over the two stars, and the other microscope over the scale reads the nearest division. Hence then, the fixed scale, and not a micrometer screw, is depended upon for the complete distance. In this way the distance between two stars on the plate can be measured to the $\frac{1}{12500}$th part of an inch.

By the measurement of such plates, we may hope to add a great deal to our knowledge of the stellar systems.

March 27, 1882.

SECTION OF PHYSICS.

The President, Dr. J. S. NEWBERRY, in the Chair.

Mr. GEORGE F. KUNZ showed specimens of marine shells (*Pectunculus*, etc.,) from "Aztec" ruins, near Salt River, Arizona, curiously cut or ground into ornamental articles, by the ancient occupants of that region.

The PRESIDENT read some notes furnished by Dr. J. B. HOLDER, in reference to the whale on exhibition at the foot of Wall street, recently captured off Montauk. He was disposed to regard it as a specimen of *Eubalæna Sieboldii*, a species belonging to the North Pacific; and, in this case, it would seem that the animal must have reached this coast by making the "northwest passage."

Mr. ARTHUR H. ELLIOTT reported for the committee appointed to prepare a memorial of the late Dr. HOLLEY; he read the following paper, which was adopted by the society and ordered to be published in the transactions:

In Memoriam.

ALEXANDER LYMAN HOLLEY, the widely esteemed fellow of the New York Academy of Sciences, was born at Lakeville, Conn., July 20, 1832. His father was once Governor of the State, and still lives at Lakeville, at the age of 77. The son, at an early age, conceived a passion for the profession that was ultimately to make him famous, and learned the trade of a machinist. He was prepared for Yale College; but, having a scientific turn, he entered Brown University, and graduated from the scientific department in 1853, at the age of twenty-one. His graduating address, on "Motive Power," shows that he was still true to his first tastes for engineering and its branches. After graduation, he entered the Corliss Works at Providence, R. I., in the double capacity of workman and student; and afterward became a locomotive engineer on the Stonington and Providence railroad. From this position, he went to the New York Locomotive Works of BREESE, KNEILAND & Co., at Jersey City, as draughtsman; and became a contributor to several technical journals. In 1856, he was owner and editor of the *Railway Advocate*. In 1857, he went to Europe to study railroad practice there; and in 1858, he published, in connection with ZERAH COLBURN, their celebrated book on European railroads. During this time Mr. HOLLEY was an active professional writer for the New York *Times*, and foretold at that day the supersedure of the side-wheel by the screw, in ocean steamers. In 1859, he went to Europe with Mr. H. J. RAYMOND, as correspondent for the New York *Times*, and met BRUNEL and SCOTT RUSSELL, the projectors of the "Great Eastern," which vessel he studied, and returned to America in her on the first trip. When writing for the New York *Times*, it was under the *nom de plume* of Tubal Cain.

About this time we also find him editing the *American Railway Review*; and in 1860, he published "Railway Practice." In the year 1862, he went to Europe to investigate ordnance and armor, in behalf of Mr. E. A. STEVENS of Battery fame; and the result of this visit was a book on these subjects published in 1865, which was translated and published in France. During this time (in 1864), he contributed 1000 definitions and several hundred figures to Webster's Dictionary.

While in England, studying ordnance and armor, he met Mr. HENRY BESSEMER, and became interested in the process of making steel, which was to render his name most famous, and give America the foremost position in the world in the manufacture of this indispensable material.

BESSEMER first announced his discovery of making steel by blowing air through molten iron, in the year 1856, at the Cheltenham meeting of the British Association for the Advancement of Science; and HOLLEY was among the first to appreciate its value. In 1862, he first became identified with this process of manufacture; and his connection with it became a series of engineering triumphs almost without parallel, till his death.

The first steel works in the United States to use the BESSEMER process were those at Troy, and the first ingot of metal was cast in 1864. Three years later the works at Harrisburg were built by Mr. HOLLEY, and he managed them till 1869. He rebuilt the Troy Works and planned the works at North Chicago and Joliet, Ill., the Edgar Thomson Works at Pittsburg, and the Vulcan Works at St. Louis. From the trial ingot cast at Troy in 1864, the industry has grown until the product of a year now amounts to more than a million of tons. And this gigantic industry owes much of its success to the active brain and patient industry of MR. HOLLEY.

In the year 1877, he was made consulting engineer to the Bessemer Steel Association of America, and became the idol of the manufacturers. He was a fine speaker and a ready wit, and there was that in his discourse that made his sentences always pleasing to the ear. From 1875 to 1876, he was President of the American Institute of Mining Engineers. During the following year, he was Vice-President of the American Society of Civil Engineers; and, in 1879, he organized and became first President of the American Society of Mechanical Engineers. He was also a member of the United States Commission for testing iron and steel.

Since 1872, he has written eighteen papers for various societies, contributed to SCRIBNER'S *Monthly Magazine*, and last, but not least, became Lecturer on Iron and Steel at the School of Mines of Columbia College. In the latter office, he was beloved of all the students who had the good fortune to hear him. His calm delivery, his carefully rounded sentences, and his pre minently practical manner of treating his subject insured an amount of attention that few lecturers enjoy. The kind answer to a question, the evident endeavor to put himself in the student's place as an inquirer, made him attractive to all, and his lectures were looked forward to, as hours of intellectual enjoyment and profit. He died in Brooklyn, January 29, 1882, from peritonitis, and lies buried in Greenwood Cemetery.

Such is a very brief record of a life that was busy beyond comparison. As a mechanical engineer, a railroad engineer, a military engineer, or a metallurgical engineer, Mr. HOLLEY could claim a position among the greatest; but when we reflect that he was eminent in each of these branches of the science of engineering, we stand bewildered at the power of brain, and the untiring energy that carried him to such a height. As a proof of his greatness, there is not to-day a man who can at once fill his place in the engineering world. But it cannot be doubted that he was prodigal of his strength, and often did more work than his wonderfully vigorous mind could bear. The tenacious metal, that he loved so well, would scarcely have been tough enough for the body to carry such a mind, and the intoxication of vigor often leads the best of us to feats of endurance from which in our calmer moments we shrink.

From every steel-works in America, from the glowing throat of every converter, there comes a radiance directed to but one point, the illumination of the name of ALEXANDER LYMAN HOLLEY; a name not to be forgotten where the watch-spring or the suspension bridge are born of American steel.

ARTHUR H. ELLIOTT, } *Committee.*
THOMAS EGLESTON, }

Prof. THOMAS EGLESTON then presented the regular paper of the evening, entitled:

THE PROPOSED GOVERNMENT COMMISSION FOR THE TESTING OF IRON AND STEEL.*

* Published in Trans. Inst. Mech. Engineers, Phila. meeting, Feb., 1882.

April 3, 1882.

REGULAR BUSINESS MEETING.

The President, Dr. J. S. NEWBERRY, in the Chair.

There was a large attendance, occupying the new lecture hall.

The report of the Council was read, recommending the election of the following persons as Resident Members:

GEORGE GREGORY, GEORGE F. STEVENS;

and they were thereupon unanimously elected.

The Council also recommended, and the Academy voted, the change in the subscription price of the Annals, suggested by the Publication Committee, viz., from $2.00 a year to the following rates:

To resident and honorary members, two dollars a year, as before.

To others, non-residents of New York City, three dollars.

To residents of the city who are not members of the Academy, five dollars.

Dr. GEORGE M. BEARD presented the paper of the evening, entitled:

A PSYCHOLOGICAL EXPLANATION OF THE SALEM WITCHCRAFT EXCITEMENT, AND THE PRACTICAL LESSONS TO BE DERIVED THEREFROM.

(Abstract.)

Dr. BEARD sketched briefly the facts of the celebrated "Salem witchcraft," and referred to the views now generally held, which have regarded it as a combination of deception, delusion, superstition and bigotry. He claimed that much in these views ought to be modified in the light of modern scientific research, and also of historical justice. He had sought to study the matter impartially, from the standpoint of scientific psychology; and after reaching conclusions which gave to his own mind a much clearer understanding of the whole phenomenon, he had visited Salem and gone over the ground as carefully as possible, only to find his conclusions more firmly established. In his view, many of the facts, alleged upon the trials of accused persons at Salem, find their explanation—now for the first time—in well-marked symptoms of the trance state, then wholly uncomprehended, and even now but little known save to specialists in that department. The men who tried and condemned the unfortunate victims of this melancholy affair were neither fools nor wanton persecutors; they were among the most cultivated and earnest men of the colony, and acted under a profound, though most erroneous, sense of responsibility. They are not to be denounced as judiciai murderers of their friends and townspeople, as has been often, and unjustly, done, but must be looked upon as honest and earnest, though sadly mistaken and unenlightened men.

A large part of the testimony on these trials consisted of that given by various young persons—the so-called "afflicted children"—to the fact of their having been bewitched by certain suspected individuals; and these children would be seized with convulsive movements upon being confronted with the persons charged. Here was, apparently, the most positive evidence, plain to all, and given before the eyes of the judges. No other explanation was then known of such facts than that of actual sorcery, which was universally believed to be the result and manifestation of an accursed compact with a personal Evil Spirit. For such diabolical intercourse, the penalty was death; and with such clear evidence of fact, and with no other explanation of those facts known or imagined, both law and logic forced the judges to condemn the accused to death.

(Dr. BEARD here produced two lads, liable to the trance condition, and called their attention to the President of the Society, occupying the Chair; first one and then the other, with no apparent cause, went into convulsions, from which they were recalled in a moment or two by Dr. BEARD, and helped into chairs, where they very speedily passed into a state of sleep.)

Here, remarked the lecturer, we have illustrated the case of the "afflicted children." He read passages from the records of the trials, where precisely such manifestations took place. The accused persons would solemnly deny the exercise or possession of any diabolical arts. They would then be asked how it was, in that case, that these children were thrown into such a state, on merely being confronted with them. To this they could give no answer, save that they knew not indeed, but that still they were innocent. The condemnation of the accused was then a logical necessity, to the belief of that time. Those who confessed were pardoned or let off with a lighter penalty; but those who denied, and protested their innocence, were sentenced to death as witches.

The only ground on which this mournful and tragical result could have been avoided, in the state of knowledge and belief two centuries ago, was the question as to the validity of testimony given by those who were possessed or bewitched. This might have afforded an escape from the otherwise inevitable consequence, and it is much to the credit of the clergy of that time that they were strongly disposed to urge this doubt and to reject the evidence thus given. COTTON

MATHER distinctly expressed his serious concern as to the acceptance of such testimony. But the lawyers and judges were not to be shaken in their adherence to the rule of legal precedent; decision after decision was cited from the old English courts, admitting such evidence in trials for witchcraft, and the more cautious and humane disposition of the ministers was overborne by the stern and rigid influence of the law. Yet this, be it remembered, is the lawyer's rule of action. The judges were bound to conform to the precedents of former procedure; and however mournful the result, and however revolting to the sentiments and beliefs of a more enlightened age, yet the Salem judges were faithful to their professional rules and their official responsibility. We must judge them by these, and not by the standards of to-day.

The Salem witchcraft was the last chapter in the long and bloody record of trials for sorcery and necromancy, which casts its shadow over many a page of European history. It had already ceased on the Continent and in England, and here in the New World colonies it had this one tragical outbreak, and then exhausted itself never to recur. It is not claimed that the views here presented are the explanation of all that then occurred; there were in some cases sinister motives actuating persons who made charges; there was in other cases, perhaps, actual deception. But it is believed that a large part of the evidence, that was most critical and most convincing, can be explained, in the way here suggested, with great ease and naturalness; and it is moreover due to the men of that time, to bear in mind the ignorance of science amid which they lived and the bonds of legal precedent in which they were held, and so to clear their memory from unjust severity of reprobation.

DISCUSSION.

A long and active discussion, covering a wide range of subjects, arose after the paper of Dr. BEARD.

Dr. BENJAMIN N. MARTIN expressed his very profound interest in the views presented. At the same time he was inclined to believe that a good deal of the testimony referred to arose from the disposition of some children to mere mischief and trickery, for the amusement afforded them in perplexing and mystifying grave and elderly persons by odd devices and pranks. He cited recent cases of marvellous "manifestations," of ghostly china-breaking and unaccountable noises, etc., finally traced to mischievous children; and questioned whether much of the Salem evidence may not have been of this kind.

Mrs. ERMINNIE A. SMITH spoke of her studies and observations among the Indian tribes on the New York State Reservations, and of the deeply-rooted belief in witchcraft, etc., that is to be found there, even where the people have taken on the externals of civilization. She proposed the question whether, in view of the credence given to spiritualism and the like among our own people, the claim of a great advance in culture and enlightenment, from these ruder, but kindred, superstitions, could be consistently maintained.

Dr. BEARD replied that, as regards spiritualism, it is precisely as Mrs. SMITH had said, a manifestation of the same kind; but the superstition is of a milder type, lacking the ferocious and tragical features that belong to the witchcraft delusion, and herein lies the advance and the improvement.

Several other members discussed various aspects of the paper of Dr. BEARD.

April 10, 1882.

The President, Dr. J. S. NEWBERRY, in the Chair.

Thirty-five persons present.

THE SECRETARY referred to the arrival, a day or two before, of the remarkably large African elephant, "Jumbo," sold from the London Zoölogical Gardens, on account of supposed vicious disposition. He noted certain of the differences between the two species of elephants, the African and the Asiatic—the former being reported as generally larger, and also readily distinguished by the great size of the ears.

THE PRESIDENT commented on the same subject, and illustrated by blackboard drawings the distinctive features of the teeth in the two species. The teeth of the Asiatic elephant, like those of our American fossil species, are crossed by parallel ridges of enamel and dentine; while in the African elephant the plates are waved in such wise as to produce not parallel, but lozenge-shaped ridges on the crown of the tooth.

Mr. F. G. WEICHMANN then read a paper entitled:

FUSION-STRUCTURES IN METEORITES.

(Abstract.)*

After referring in general to the peculiar interest which attaches to meteorites, and the uncertainty as to their real nature which is still felt

*This paper is printed in full in the ANNALS of the Academy, Vol. II, No. 10.

among scientists, Mr. WIECHMANN alluded briefly to four principal theories of their origin, as (a) Terrestrial Volcanic, (b) Lunar Volcanic, (c) Planetary, or (d) Cometary. There are many objections to the theories that regard them as belonging to the earth or its satellite, on the one hand, or as visitants from distant space, on the other; and preference is doubtless due to the view that these bodies belong to the planetary system—perhaps as fragments of asteroids that may once have collided. As regards the differences in their mineral and chemical characters, which have led to various classifications, that of DAUBREE alone was given. According to him, meteoric stones are divided into (1) Siderites and (2) Asiderites, according as they are composed of metallic iron (wholly or partly), or do not contain that substance. The former class, the Siderous meteorites, he again divides into Holosiderous, Syssiderous, and Sporasiderous—according to the amount in which the iron is present. Various analyses of meteorites were then given.

Mr. WIECHMANN next proceeded to his own researches upon meteorites, describing the manner of examining microscopic sections, and certain adjustments thereof with reference to the use of polarized light. A list of seventeen specimens was given, with the dates and localities of their fall, from which he had prepared and studied numerous sections, and also of various volcanic rocks examined in the same manner for comparison. His attention had been chiefly given to certain very peculiar and characteristic forms which are found in many meteorites, and to which he gave the designation of "*Fusion-Structures.*"

These structures are not crystal forms, as they lack the definite angular character that belongs to the latter; their outlines are often rounded, and their aspect curiously suggestive of organic structures. They might fall under ZIRKEL'S definition of what he calls *crystallites*, i. e., mineral formations possessing a radiate arrangement or grouping, but not showing, either as a whole or in their parts, any regular properties or outlines of crystallized bodies. It is these "fusion-structures" which have been regarded, in the recent well known work of OTTO HAHN, as representing true organic remains.

The structures of this kind which Mr. WIECHMANN had found in the sections prepared by him, were then described, and illustrated by a series of very finely prepared drawings, displaying their characters as seen at various magnifying powers, from 75 to 1500 diameters. It was shown that, in some cases, the organic aspect, presented under a low power, disappears entirely upon greater magnification. After discussing these, the author declared his inability to discover any forms that seemed really organic, and criticised various points asserted in Dr. HAHN'S work, as distinctly negatived in his own observations.

The sections of volcanic rocks were then shown and described in the same manner as those of the meteorites had been ; and the interesting result was brought out, of a very close similarity in the microscopic structure of various specimens of these two classes of bodies. Whatever theory be held as to the origin of meteorites, that of volcanic rocks is sufficiently known and universally admitted : they have cooled from a state of fusion. If, therefore, a likeness of internal microscopic structure appears in the two kinds of bodies—besides in many cases a close resemblance in composition—we may safely conclude that meteorites also have passed through a fused condition, and that the structures in question have originated in them as they have in volcanic rocks.

Numerous other points were treated of in this paper, *e. g.*, the probable origin of the "crystallites" or "fusion structures" in igneous rocks, as due to unequal rates of cooling among the different constituents of the fused mass, resulting in the segregation of minute portions scattered through the rock ; also the effect upon meteorites of the friction-heat developed in passing through the earth's atmosphere, which effect is plainly shown in the sections, but is seen to be only superficial. For these and other details, reference must be made to the article as published in the Annals.

DISCUSSION.

Prof. R. P. WHITFIELD, DR. NEWBERRY and others discussed the paper briefly, agreeing with the views therein expressed, and welcoming its presentation, and also dissenting entirely from the views of Dr. HAHN, as to the presence of organic remains in meteorites.

April 17, 1882.

LECTURE EVENING.

The President, Dr. J. S. NEWBERRY, in the Chair.

A large audience was present.

CHEVALIER ERNST VON HESSE-WARTEGG delivered the lecture of the evening.

THE SUBMARINE TUNNEL BETWEEN ENGLAND AND FRANCE.

(Abstract.)

In regard to the necessity of such an enterprise, reference was first made to the well-known and very peculiar discomforts of the passage of the Channel in boats, and to the aggravation thereof by the poor construction and worse management of the steamers employed. Instances of these grounds of criticism were given as examples, and of the natural difficulties, moreover, which often involve great and unavoidable delays and irregularities in the transit of both passengers and mails. Under these circumstances, the great desirableness of some improved means of travel is apparent at a glance, when it is remembered that a country of 30,000,000 of inhabitants is to be connected with a continent of 300,000,000, and that some 700,000 passengers annually make this passage.

If the commercial aspect be regarded, it is found that the yearly interchange of products between England and the continent amounts to a hundred millions of pounds sterling in value, and employs vessels aggregating a tonnage of ten millions. There could be no question of the financial success of such an undertaking as the proposed tunnel, where so large a business in both freight and passengers is subjected to so many inconveniences. If America had been similarly situated, such a work would long since have been accomplished; but the conservatism and the political anxiety of the English people have interposed serious obstacles.

Some seven years ago the proposal was first discussed, and the financial and engineering possibilities were largely debated, but no political difficulties were then raised. Only of late has this aspect been presented, and a formidable opposition made to the construction of the tunnel, on the part of both the people and the Parliament of England. This objection the lecturer considered most unwise and unjustifiable, a selfish hindering of a great enterprise of general importance and advantage. The St. Gothard Tunnel, or the railway over the Pyrenees, would be open to the same objection of a possible political danger; but none of the nations thus connected had for that reason opposed these great works of intercommunication. Nothing could be easier or simpler than to guard the entrance to a tunnel, especially when that tunnel lies beneath the sea, and could be flooded and closed at the first intimation of a foreign invasion.

Turning to the scientific aspect of the work, reference was made to the character of the material in which the tunnel is to be wrought. This is found to be chalk throughout, the well-known chalk of the Dover cliffs extending under the channel all the way. The work of excavation is therefore easy; the question might arise, however, how far this soft rock would prove impervious to the water. This had been tested by careful experiments; and it was proved that, even under heavy pressure, a small thickness of chalk allowed scarcely any perceptible passage to water.

The construction of the tunnel was next described, and illustrated by drawings. Its general section-form would be that of a low horse-shoe, nineteen feet in width by twenty-four in height. The whole would be lined with brick; but this brick wall and arch would not be quite in contact with the chalk excavation, but a space was to be left between, to allow any percolating water to pass down without entering the tunnel-way and escape beneath its floor. This escape would be secured by the slope of the tunnel, which is to be highest at the middle and descending somewhat toward each end, where large reservoirs will be excavated for any accumulating water, which will thence be removed by powerful steam pumps, raising it through shafts to the surface. The important matter of ventilation is to be provided for by engines at either extremity, so working as to insure a steady and powerful current of air through the entire tunnel, one pumping air, and the other exhausting it.

The machinery employed in the work of excavation was also referred to and illustrated; but it is peculiar and complicated, and cannot be well described, save at length and with figures. In working through the comparatively soft chalk, the process is strictly one of cutting; and a very ingenious and beautiful machine is employed, wherein a series of blades, like knives set upon revolving wheels, is made to cut the chalk at the extremity of the boring. The machine itself is also advanced on wheels, as it works onward the heading from day to day. Thirty-six feet is about the daily rate of progress; and it is computed that the whole will be finished in five or six years.

Estimates were then given of the profits which it is expected will be realized, if the work is successfully completed. The amount of funds requisite to do this will be forty to fifty millions of dollars; say, ten millions of pounds sterling. Three-fourths of the present passenger traffic should, it is altogether probable, prefer the tunnel to the channel voyage; and, considering the advantage in freight-transit of not "breaking bulk" for shipment, the receipts may be estimated roughly as follows:

Passenger travel	£850,000
Freight	300,000
Mail service, etc	50,000
Total	£1,200,000

Deducting from this, say, forty per cent. for expenses (£480,000), or somewhat less, there will remain a profit of £720,000, or more, which would yield from seven to seven and a half per cent. yearly on the capital of £10,000,000. If this capital seems large, it is not so in comparison with the sum already invested in the English railways, which amounts to about £700,000,000.

For his own part, the lecturer was fully convinced alike of the need, the practicability and the financial success of this great enterprise; and he had no doubt that ladies and gentlemen now in his audience would yet pass through this submarine tunnel, on their way between Paris and London.

At the close of the lecture, complimentary remarks were made by the PRESIDENT and Dr. B. N. MARTIN; and on motion the interest and gratification of the Academy was expressed in a resolution of thanks to COUNT WARTEGG.

April 24, 1882.

SECTION OF GEOLOGY.

The President, Dr. J. S. NEWBERRY, in the chair.

Twenty-seven persons present.

The receipt of interesting letters from Dr. JULIEN, the recently elected Vice-President of the Academy, was announced by President NEWBERRY, with notes of much scientific value regarding the explorations in which he is engaged in the islands off the coast of Venezuela, particularly on Aruba. Dr. JULIEN reports there large guano deposits, and discovers proofs of a series of repeated changes of level. He is collecting in several departments of zoölogy, and will have much interesting matter to lay before the Society on his return.

Dr. JULIEN proposed the name of the Governor of the island of Buen Ayre, JOHAN F. W. GRAVENHORST, a gentlemen of scientific culture, as a Corresponding Member of the Academy, and he was at once unanimously elected.

Dr. B. N. MARTIN referred to the very remarkable display of aurora during nearly the whole night of the 16th inst., as did also the President. A brilliant corona was formed; the entire sky was covered with tremulous sheets and waves of white light; and all the telegraph wires were rendered useless for a time in New York, while the disturbance reached widely over the country and even affected the submarine cables.

The death of one of the oldest Fellows of the Academy, Mr. WM. H. LEGGETT, was announced by Dr. MARTIN, and he and the President gave outlines of the personal and scientific record of Mr. LEGGETT, of his scholarly attainments, especially in Greek, of his great devotion to botany, and of his long interest in the Academy and its work.

The President also announced the death of the eminent Mr. Charles R. Darwin, Honorary Member of the Academy, and discussed the great importance of his labors in enlarging the modes of investigation in biology.

Prof. John J. Stevenson then read the following paper:

THE MINERAL RESOURCES OF SOUTHWEST VIRGINIA.

The Virginias were surveyed by Prof. W. B. Rogers and a competent corps of assistant geologists during the five years previous to 1841, but the final report was not published and only a few copies of the annual reports were printed. The latter are now so rare that practically the only available information respecting the geology of Virginia is that obtained by examinations made for private parties or corporations.

The region to which attention is called extends from New River to the Tennessee line, and lies between the Great Valley of Virginia at the southeast and the State line at the northwest. It is drained by the Clinch and Holston Rivers, except in the northeast, where the waters flow into New River, a tributary of the Ohio.

The surface is rugged throughout, there being nine ranges of mountains between Bristol on the Tennessee border and the Kentucky line, a distance of little more than forty-five miles. Some of these ranges are very abrupt, and water-gaps are widely separated; so that between the Tennessee line and New River, a distance of not far from 120 miles, only two really good railroad routes have been found from the Valley to the coal-field, and these are available only for narrow-gauge roads.

This ruggedness is due to upthrow faults, of which seven occur between the Valley and the coal-field, a distance of about thirty miles. The Medina, the great mountain-making rock of the Appalachian region, is brought up four times in the interval. The effect of these faults on the agricultural conditions is curious, for the area is divided into alternating poor and rich valleys; the former underlaid by the Upper Silurian or Devonian shales, while the latter show the Lower Silurian limestones. Some of these faults are stupendous, bringing the Knox sandstone into contact with the Quinnimont Group, a vertical extent of not less than 8000 feet. While these faults have led to the removal of the coal beds almost wholly from the faulted area, they have made fair amends by bringing to the surface more than once the ore-bearing groups known as the Lower Helderberg, Clinton and Knox or Calciferous.

The existence and excellence of the iron ores of Southwest Virginia have been known for many years; but the chief interest of the region now centers in the coal deposits, whose value and accessibility have been ascertained very recently. The coal occurs at three horizons:

The Coal Measures,
The Quinnimont Group,
The New River Group.

The area of the *Coal Measures* in Virginia is comparatively small, probably less than 600 square miles, the greater part of the field being in Kentucky and West Virginia. It occupies portions of Lee, Wise, Russell and Buchanan Counties, lying along the Kentucky border. The most readily accessible part is that in Lee and Wise Counties, and is drained by Powell River, a large stream entering Clinch River near Knoxville, Tennessee. Stone Mountain, a bold ridge of vertical conglomerate and the southeastern wall of the coal-field, is broken by two gaps, through which the Powell River and its North Fork flow. These can be reached by following the river from Knoxville, or by a shorter, though more difficult, route from Bristol, on the Norfolk and Western Railroad. The latter route has been chosen, and a narrow-gauge railway is in course of construction.

Measurements on the head waters of Powell River, behind the "Big Stone Gap," afforded me a vertical section of nearly 2500 feet of Coal Measures, containing twenty-one *coal beds*, varying in thickness from four inches to fifteen feet; but the productive part of the section is confined to the lower 920 feet, the beds higher up being very thin. This section doubtless represents all the Coal Measure groups of Pennsylvania, but detailed comparisons are impossible for the present, there being no limestones or other fixed horizons to be used for that purpose.

Four of the *coal beds* deserve notice. Two beds of *splint* are found high up in the productive portion of the section. They are separated by an interval of 70 feet, and are from 3 feet 6 inches to 4 feet thick. Their coal is a hard gray splint, very like that obtained on the Kanawha. Analyses by Mr. A. S. McCreath show that this Powell River splint contains little more than 3 per cent. of ash and less than one-half of one per cent. of sulphur. The *Kelly Coal-bed*, 215 feet below the lower splint, is from 2 inches to 15 feet thick, but in a large part of the area maintains a thickness of from 5 to 7 feet. The middle bench, 2 feet 6 inches thick, is an admirable *gas coal;* the lower bench is a fair splint, while the upper bench is worthless. Mr. McCreath found in the middle bench, .890 per cent. of ash, .771 per cent. of sulphur, while the volatile matter is 38.850. The *Imboden bed* is 50 feet below the *Kelly*, and varies in thickness from 6 feet 11 inches to 8 feet 5 inches. Its top bench is splint, about one foot thick, which gives excellent support to the roof. The rest of the bed yields an admirable coal, somewhat softer than the Pittsburgh, but harder than the Connellsville, so that it will bear shipping very well. A section of this bed yielded Mr. McCreath: Volatile combustible matter, 35.920; Sulphur, 0.594; Ash, 1.515. This is an excellent *coking coal*, and its coke should contain not more than three or four per cent. of ash with a half per cent. of sulphur. Its excellence will be seen by comparison with Connellsville coke, which contains 9 to 13 per cent. of ash, or New River coke, with 6 to 7 per cent., or Oxmoor coke, with 5 to 6 per cent. Some of the lower beds in the section are workable, but in view of the larger beds, they are unimportant.

As this area lies beyond the faulted region, the dip is gentle. The forks of Powell River are long and flow in deep gorges, so that an enormous area can be worked without resort to artificial drainage. It is estimated that from 50,000 to 70,000 acres can be reached in this way at the head-quarters of Powell River, and that an area half as large is equally available on the North Fork of that stream.

This series is persistent in Russell and Buchanan Counties, where beds apparently answering to the *Lower Splint*, *Kelly*, and *Imboden*, have been discovered; but the character of the coal has not been tried.

The *Quinnimont Group* of Virginia and West Virginia is equivalent to the Seral or Pottsville Conglomerate of Pennsylvania. It is unimportant in Lee and Wise Counties, attains its maximum importance before New River is reached, and thence gradually decreases, until in Randolph County, of West Virginia, it again becomes unimportant. The series is 1000 feet thick on Powell River, where it has six coal beds, all very thin and without value except to supply domestic fuel. A section of about 600 feet of the lower part of the group was obtained on the Laurel Fork of Bluestone Creek, at the eastern end of Tazewell County. This shows 9 coal beds, varying in thickness from 6 inches to 11 feet. This area can be reached without much difficulty, from the Chesapeake and Ohio Railroad, or by a route following New River from the Norfolk and Western Railroad to the mouth of East River, and thence up the latter stream to its head, where, by crossing a narrow summit, the Laurel Fork is reached. A road is in course of construction along the latter route. Two of the *coal beds* merit especial attention. The *Nelson bed* shows from 5 to 9 feet of coal, the thickness being greatest on Laurel Fork, but less and less as one goes thence toward New River. The *Coal Branch bed*, 60 to 70 feet higher in the series, is from 5 to 8 feet thick, the latter on a branch of Laurel Fork. The quality of both these beds appears to deteriorate eastward. Analyses of these coals from Laurel Fork, made by Mr. McCREATH, show the volatile matter to vary from 20 to 21 per cent.; the sulphur from 3 to 4-tenths of one per cent.; while the ash is little more than 2 per cent. For the most part, the dip of these beds is gentle, and they are available for a long distance. The coal is very soft and will not bear handling, but it can be mined very cheaply. Its coke is marvelously clean, and should be fully equal to that manufactured on New River. It should be as pure as that from the Powell River coals; but the low percentage of volatile matter will detract from its strength. At the same time, the volatile portion is greater than in the Broad Top and New River coals, both of which yield coke which bears well the burden of 60 feet stacks.

The *New River Series* belongs to the Vespertine or Pocono of Pennsylvania. The coal bearing part of this group is wanting in Scott and Lee Counties, but it develops rapidly north-eastward, where it has been studied by Lesley and Fontaine. The beds attain their greatest thickness in the south-eastern side of the area, where, along-side of the faults, small patches have escaped erosion. Some of the beds are from 5 to 8 feet thick; but, for the most part, the coal is inferior in quality and contains much ash. The volatile matter is low, and the coal is usually spoken of as anthracite or semi-anthracite; its economic value is insignificant.

The *iron ores* are brown hematite and "fossil ore" (Clinton), with here and there a little magnetite. The Lower Helderberg yields brown hematite, which fills pockets or cavities in the limestone. This ore abounds in Scott and Wise Counties, on Clinch River and its tributaries; but its quality varies annoyingly. At some localities it is very sandy, while at others it is clean enough for Bessemer treatment. Mr. McCREATH'S analyses show the variations to be: Metallic iron, 41. to 52.; Sulphur, .030 to .060; Phosphorus, .057 to .890; Insoluble matter, 7.840 to 22. The ore from some of the pockets has been smelted in open-hearth forges.

The *Clinton* ores have been brought up along five lines, most of which are unbroken from New River to beyond the Tennessee line. The importance of these ores was recognized by the Director of the third Geological Survey of Kentucky, and a corps carefully studied and reported on the series as shown along Stone Mountain for 60 miles from the Tennessee line. These ores are rather higher in metallic iron than those of the same series in Pennsylvania, and are very low in phosphorus, seldom showing more than 11 hundredths of one per cent.

The *Calciferous* ores, those of the Knox group, are exposed in a broad area. They occur in great pockets, and have been prospected extensively within the mountain area of Scott and Russell Counties, within the last fifty years, to supply a forge in the former county. These ores are the same with the brown hematites of the Great Valley, on which all the furnaces between New River and the State line depend for supply. For the most part this ore is of excellent quality, and Mr. McCREATH'S analysis shows 58 per cent. of metallic iron, with only 75 thousandths of one per cent. of phosphorus, and less than 4 per cent. of insoluble matter. It is not improbable, however, that the ore may average higher in phosphorus than the sample analyzed.

Manganese occurs with these Lower Silurian ores, and sometimes it is of excellent quality. At one locality ore was obtained which has 81.45 per cent. of oxide of manganese, with but 27 thousandths of one per cent. of phosphorus.

The Tennessee marbles, belonging to the Trenton Group, must not be overlooked. These occur in the area lying behind Clinch Mountain, where the quantity is almost inconceivable. A number of samples from Estillville, in Scott County near the State line, were polished, and eight of them were regarded by dealers as belonging to the first grade.

The following paper was read by title:

"INDEX TO THE LITERATURE OF ELECTROLYSIS AND ITS APPLICATIONS, 1784–80;" by W. WALTER WEBB, assistant in the Scientific department of Trinity College, Hartford, Conn. This paper will appear in the Annals, forming another member of the series of Indexes to the Literature of Chemistry, therein contained.

May 1, 1882.

REGULAR BUSINESS MEETING.

The President, Dr. J. S. NEWBERRY, in the Chair.

The report of the Council was read, recommending the election to Resident Membership of

Rev. EDWARD PAYSON THWING,

Rev. B. F. DA COSTA.

Their election was voted unanimously.

Mr. W. LECONTE STEVENS exhibited and described

AN IMPROVED FORM OF ORGAN-PIPE SONOMETER.*

Dr. B. N. MARTIN read an extended notice of the life and works of the late Prof. JOHN W. DRAPER.†

* Published and illustrated in the American Journal of Science, 1882.

† Published in full in the Magazine of American History, 1882.

May 8, 1882

SECTION OF BIOLOGY.

The President, Dr. J. S. NEWBERRY, in the Chair.

Forty-three persons present.

Mr. G. F. KUNZ exhibited choice specimens of several varieties of feldspars, including "moonstone" from Ceylon, and from Chester County, Penn., "sunstone" from Chappaqua, N. Y., oligoclase from Norway, etc.

He also announced the death, on May 5, of a Corresponding Member of the society, Mr. WILLIAM S. VAUX of Philadelphia, long eminent as a mineralogist, and a leading patron of science in the city of his home. Mr. KUNZ made special reference to the extent and elegance of his celebrated collection.

The PRESIDENT spoke further of Mr. VAUX, and particularly of his active connection with the Academy of Sciences of Philadelphia, and with the American Association for the Advancement of Science.

Prof. H. L. FAIRCHILD then gave the address of the evening, largely illustrated with blackboard drawings and lantern views, on the subject of

METHODS OF ANIMAL LOCOMOTION.

(Abstract.)

Self-motion is the most prominent characteristic of life. This remarkable power of overcoming the forces of Inertia and Gravitation is not confined to animals. Many plants have, besides the capability of upward growth and extension, more or less motion of some organs. In the lowest forms of life, plants and animals can not be distinguished by their locomotive powers. Many microscopic plants move about in water as lively as animals, and propelled by similar organs. Nor can the movements be distinguished as voluntary in animals and involuntary in plants. Consciousness and will are not more evident in the lowest animals than they are in the Venus Fly-trap and the Sensitive Plant.

It is doubtless true that all animals can move from place to place at some period of their life. For example the coral polyp, oyster and barnacle possess locomotive powers only in the embryo state, becoming fixed in the adult ; while in some other animals, as the jelly-fish these conditions are reversed.

The means of locomotion are exceedingly various. The lowest method is exhibited by the amoeba, in which progression is secured by change of shape of the entire mass of the unicellular body. The power of movement here resides in the unorganized protoplasm, without any organs whatever. Even in the lowest form of life there is a conversion of *Vital* force into *Physical* force.

Higher in the animal scale we find motion by means of cilia. These are minute elastic filaments which have a whip-like motion—alternate flexion and extension. But the cilia do not seem to be controlled necessarily by the creature's will. The motion is evidently automatic. Many low plants, as well as animals, have the body covered with cilia by which they tumble about in the water very lively. In some of the infusorians, however, the cilia seem to obey the animal's will.

The means of motion in all higher animals is muscular tissue. This is a highly specialized tissue, subjected to the nervous system, and which concentrates the power of movement, which in the amoeba was diffused through the whole mass of the body. Muscular power resides in the contractility of the cells. Expansion of the cells or the extension of the whole muscle is produced by elastic reaction—a merely physical force—or by contraction of opposing muscles. Muscles act under nervous, electric or other stimulus; but sometimes no stimulus seems necessary.

The organs and methods by which the vital contractile force of muscular tissue is utilized in producing mechanical power is a most interesting study. [With the magic lantern a few of the more typical and interesting methods of locomotion in animals were shown.]

A few animals move without organs, as the sea-anemone in crawling or the jelly-fish, leech, and snake in swimming. But most animals have parts or organs specially adapted to locomotive purposes. The old classification of swimming, flying and walking will answer our purpose.

Locomotion in water requires much less effort than locomotion in the air, and more than locomotion on solids. But the organs for swimming are comparatively simple. The lobster swims backward by its tail fin, which is a combination of beautiful oars. The squid swims in any direction, by ejecting the water of respiration out of a flexible tube.

Swimmers *par excellence* are the fishes. They propel themselves chiefly by their tail fin, used as a horizontal scull oar. The remaining fins are used to guide and control the motion. The paired fins are based upon the arm and leg bones. The rays fly through the water by means of the pectoral fins and side expansions of the body. The whale propels himself by the vertical motion of the body and tail Frogs, turtles, crocodiles and many birds are especially adapted to a life in water.

Locomotion in Air.—On account of the extreme rarity of the atmosphere, flight requires special apparatus and structure and very great muscular power. But insects and birds outstrip all other creatures. Their whole structure is wonderfully adapted to aerial life; the skeleton light, the body filled with air, the wings elastic and light, but firm, and the wing muscles exceedingly powerful. Wings of birds are quite similar in principle and structure, but wings of insects greatly differ. Three classes of insect wings may be noticed: the transparent wings of the bee, fly, etc.: the dense opaque wing covers of the beetles: and the scale-covered wings of the butterfly and moth.

The wing of the bat is an expansion of skin stretched upon the long fingers and from arm to leg. Dragons passed away with the age of reptiles. The so-called flying dragon has only a parachute of expanded skin, by aid of which it can sail downward through the air. The flying squirrel has a similar apparatus. In the flying-fish, the pectoral fins are very large, and serve a similar purpose. Some spiders are able to sail the air by means of kites or sails made of their silken webs.

Locomotion on Solids.—A much greater variety of organs are used for moving on solids. The leech, star-fish and cuttlefish employ suckers, which are little cupping glasses or diminutive water-pumps. The earth-worm has minute spines, and the serpent large scales or scutes on its belly; caterpillars have pins rather than legs. The foot of the clam is a fleshy protuberance which can be pushed into the sand, enlarged at the end and then shortened. The snail glides over the surface by sets of short muscles in the under side of its body; flies adhere by a fluid, exuded by the hairs on the surface of their foot discs.

Of jointed limbs the millipede has, in some species, two or three hundred. The centipede has thirty or forty legs; crabs and lobsters have ten legs, but two used as pincers. The spider has eight legs, and the true insects have six legs. The reduction in the number of similar organs indicates advance in locomotive powers.

As the skeletons of all vertebrates are built on the same general plan, the four limbs of all show a certain resemblance; of course, the similarity is most evident in the legs of quadrupeds.

The limb bones of fishes are in nearly all cases within the body, as the basis of the paired fins. But in some fishes they are sufficiently developed to be useful for crawling. In reptiles the limbs are generally awkward on land, although some lizards are agile. The legs of birds are highly specialized.

While mostly intended for running on land, the mammals nevertheless exhibit a greater diversity of organs and methods of locomotion than any other class of animals. Here we find the swimming whale and seal, the flying bat, the sailing lemur and squirrel, the creeping sloth, the jumping kangaroo, the swinging monkey and the swift running quadrupeds.

The arms and legs of the running mammals are highly developed, and the mechanical construction and action of the parts are beautiful and wonderful. The muscles of the body are largely grouped about the shoulders and hips.

The arms are usually straight, but in the swifter animals, as the deer and horse, the legs are considerably bent. In the elephant the legs are straight columns supporting the huge body.

The normal number of phalanges is five, but there is great variation. The hoofed quadrupeds may have three, as the rhinoceros : two, as the ruminants: or one, as the horse. Some mammals walk on the whole sole of the foot, as the bear and man, termed plantigrade ; others on the toes, as the cat and dog, digitigrade ; while the foot of the seal is termed pinnigrade, and the hoofed quadrupeds, ungulate.

May 15, 1882.

Lecture Evening.

The President, Dr. J. S. Newberry, in the Chair.

The hall was filled by a large audience.

The closing lecture of the monthly course for the season was delivered by Prof. H. Carrington Bolton, Ph. D., of Trinity College, Hartford, Conn., on the subject of

GLACIERS.

The lecturer treated of the chief glacier regions, especially those of the Alps, of the various physical phenomena presented by them, of the several theories of ice motion, and of personal experiences in travelling among glaciers, illustrating the whole with a varied and striking series of photographic lantern views.

May 22, 1882.

Section of Geology.

The President, Dr. J. S. Newberry, in the Chair.

Twenty-two persons present.

Prof. O. P. Hubbard, exhibited a peculiar organic salt, malate (or, perhaps, bi-malate) of lime, from Williamstown, Vt., derived from the sugar-maple. In the manufacture of the sugar, the syrup, when ready to crystallize, is strained through a flannel filter, and this substance is thus obtained, as a fine white or buff crystalline powder. He had long known it, as obtained rarely and in small amounts at Hanover, N. H., in the mica-slate region ; while from the towns in Vermont, where the rocks are more calcareous, it is common and abundant. At Williamstown, there are springs that deposit calcareous tufa.

The substance is popularly called "sap-sand" and "sugar-nitre;" in Steele's "Fourteen Weeks in Chemistry," it is referred to as *silica!*

The PRESIDENT remarked upon the power of plants to select their food from the soil, and to form organic salts by laws and processes as yet largely unknown to us.

Various minerals were exhibited by Mr. G. F. KUNZ and Mr. W. L. CHAMBERLIN.

Capt. J. H. MORTIMER showed specimens of granite, compact and disintegrated, and of the resulting kaolin, from the Island of Jersey; also, a specimen of the red syenite, of the Egyptian obelisk set up on the banks of the Thames, similar to the one now here.

The subject of the disintegration of granites and the production of kaolin, was further remarked upon, and examples cited from various localities [Mystic, Conn., the White Mountains and New York Island], by the PRESIDENT, Prof. O. P. HUBBARD and D. S. Martin.

A paper by Mr. ISRAEL C. RUSSELL, was then read by Prof. MARTIN, entitled:

SULPHUR DEPOSITS IN UTAH AND NEVADA.

Sulphur deposits of sufficient extent to attract attention from their economic importance have been visited by the writer at three localities in the Great Basin. These are located at Cove Creek, Millard County, Utah; near Humboldt House, Humboldt County, Nevada; and at Rabbit Hole on the eastern edge of the Black Rock desert in North-western Nevada.

Sulphur Deposits at Cove Creek.

Of these deposits, the most interesting to the geologist are those occurring at Cove Creek in Southern Utah. This locality is on the eastern border of the Great Basin and at the western edge of the region of the high plateaus recently described by Captain DUTTON. Eastward is a high range of trachytic mountains, that sweep around to the northwest and southeast, forming a crescent-shaped alcove in the western face of the range, the points of which are about ten miles apart. Between the horns of this crescent, and three or four miles southwest of the Ranch Fort at Cove Creek, is a conical mountain of basalt, having the ruins of a cinder cone at the summit; for convenience we shall call this old volcano the Cove Creek crater. From the perfection of its outlines, this crater seems to be of a very recent date, but is clothed with a scattered growth of cedars. Judging from its general appearance and the amount of weathering it has suffered, it is probably older than the post-Bonneville craters near Fillmore, Utah. The Cove Creek crater is now in the condition of a nearly extinct fumerole, as hot air and gases are said to escape from cracks and fissures near the summit of the mountain. The area, between the base of the crater and the mountains to the eastward of Cove Creek, is occupied by subaerial gravels, except along the immediate base of the eastern range, where volcanic tuffs appear at a number of localities. Along the line where the alluvium slopes upward to meet the tuffs and volcanic rocks, is where the majority of the sulphur mines have been opened.

Prospecting for sulphur was begun at Cove Creek, about ten years since, by Mr. C. A. SEMLER, and has been carried forward by him with much energy ever since. At the present time fifteen mines have been located, a few of which have been developed to a slight extent, and a large number of prospects opened. The mines, however, have not yet been worked sufficiently to make the sulphur from this locality an article of commerce.

From the hasty examination that I was enabled to make, I find tha the sulphur deposits at Cove Creek arrange themselves in three convenient groups, the divisions depending, however, more on the nature of the cavities that have received the sulphur, than on any difference in the manner in which it has been introduced. In one instance the sulphur occupies a nearly extinct solfatara; again we find it impregnating and cementing beds of volcanic tuff; at other times, the sides of fist sures are sheathed with a brilliant drusy lining of sulphur crystals. In all of these instances it is evident that the sulphur has been derived from deeply seated sources, having been expelled in a gaseous form and condensed and crystallized in the cavities and fissures in the cooler rocks above.

In the mine named the *Cleveland* by Mr. Semler, situated about two miles southward of the fort at Cove Creek, the sulphur occurs in quantity, filling the crater of a solfatara. The bottom of the little valley, in which the Cleveland is situated, is nearly circular, with a diameter of about 1200 feet, and is totally destitute of vegetation. Over the level surface of the strange little desert the sulphur outcrops in many places, forming ledges of sulphur; and a number of prospects show an abundance of quite pure material. A shaft was sunk in the centre of this deposit, to the depth of twenty-five feet, all in pure sulphur, as I was informed by Mr. Semler. The material taken from this shaft has been returned to it, in order to guard against the burning of the mine, and the broken fragments are now cemented into a solid mass by the sulphur that has been deposited in the interstices between the broken masses. The deposition of sulphur is still in progress, the prospecting holes becoming lined in a few days with most beautiful plumb-like crystals of pure sulphur. The temperature in all the openings in this sulphur bed is high. At the surface of one of the prospecting holes which had been refilled with broken fragments, the thermometer read 104° F.; and through all the openings vapor and heated gases are constantly escaping. In cold weather the clouds of vapor forming above this mine may be observed from a distance of a mile or two. The drops of moisture that condense on any cold object held for a moment in the excavations, are intensely acid, and from their taste seem to a contain a large proportion of sulphuric acid. No chemical examinations of these acid drops or of the gases that are constantly escaping from the openings could be made. It is noticeable, however, that no odor of sulphuretted hydrogen can be detected about the mines; but from a few simple tests, and from the presence of dead animals in a large number of the openings, it seems evident that carbonic acid is exhaled in large quantities. The sulphur at this locality covers a circular area of about 1000 feet in diameter, and, from the prospects that have been reported, cannot be less than twenty-five feet thick. This is not pure sulphur, however, but certainly carries a large percentage of earthy matter.

The conclusion arrived at, from a hurried inspection of this interesting locality, is that the sulphur fills a nearly extinct solfatara, into which it has been conducted from below, seemingly by direct sublimation, or, what is perhaps more probable, by the decomposition of sulphurous gases, and the deposition of the liberated sulphur. A careful examination of the fumes that are exhaled from these openings would certainly be of much value in determining the chemical history of sulphur deposits.

Of the second class of mines—those in which the sulphur impregnates beds of volcanic tuff—we have examples in the *Mariposa* and *Prince Albert*, situated at the base of the mountains, two miles east of the fort at Cove Creek. At these localities the tuff is stratified, and contains scattered pebbles of quartzite and limestone, and is impregnated over a large area with sulphur, which fills all the interstices of the rock. Judging by the eye alone, much of the tuff contains from ten to forty per cent. of sulphur, while in localities the rock is far richer than this. Overplacing the tuff are alluvial cones of gravel, that are in some places cemented by sulphur in the same manner as the strata of tuff beneath, thus showing that the beds now carrying the sulphur have acted simply as condensers for the sulphur, which in every case has been derived from a deeper source.

The third class of sulphur deposits—those in which the sulphur forms a lining of crystals on the sides of fissures—are illustrated by the *Philadelphia* and *Mammoth* mines. At the first of these, situated one mile north of Cove Creek, the sulphur occurs in drusy crystals covering the sides of small intersecting fissures in trachyte. The rock has here been much broken along a line of faulting, which may be traced southward to the top of the Cove Creek crater. The Mammoth mine is of a similar character, but found in dark carboniferous limestone. This mine is located on the top of the divide between Cove Creek and Dog Valley to the northward. While standing on this pass, the line of faulting, on which the Mammoth mine is situated, may easily be traced southward to the valley of Cove Creek ; and across the valley it is again seen as a bold fault-scarp, with a throw to the westward, ascending the side of the volcanic crater that we have already mentioned several times. The fault crosses this cone just to the east of the summit, and has given the eastern slope of the mountain a steeper inclination than is shown by the western side. Northward from the Mammoth mine the same line of faulting is continued for many miles, and shows a recent scarp all along the eastern border of Dog Valley. The fault-scarp that ascends the side of the volcanic cone, and also the recent scarp in Dog Valley, are the results of slight and very recent movements along an ancient line of profound displacement. The volcanic mountain southwest of Cove Creek has been built over this old line of fracture. The sulphur in the Mammoth mine has been deposited in the fissures made by the faulting of the strata, and in the seams and openings between the layers of limestone. The rock on the borders of these fissures, beneath the thin lining of sulphur, has been altered to a brown earthy mass, to the depth of about half an inch. The mines, like the Philadelphia and Mammoth, that have been opened on lines of fracture in solid rock, show but little sulphur, and on the whole cannot be considered as giving promise of any large deposit below the surface. In these mines also the temperature is high, but not so great as at the Cleveland.

The beds of volcanic tuff, in which the sulphur has been deposited, probably rest on harder rock that has been fissured, thus allowing the sulphur-bearing vapors to escape upwards, as in the case of the Philadelphia mine; but no section showing the tuff beds above such fissures has been exposed. As these beds of tuff occur for many miles along the base of the mountains, we may hope that the conditions for charging them with sulphur have been many times repeated. Next to the Cleveland mine, we should certainly look to the beds of tuff, along the base of the mountains eastward of Cove Creek, for the principal supply of sulphur for economic purposes from this region.

Owing to the exhalation of noxious gases in nearly all the prospects that have been opened, we find in the bottoms of the excavations large numbers of dead insects, together with the remains of mice, bats, rabbits, etc., that have been smothered by the escaping gases. In many of the openings a choking sensation is felt, and the amount of gas, which seems to be largely carbonic acid, is so great that a person can remain in them but a few seconds. Even in shallow prospects the workmen have to fan each other, in order to remain in the openings long enough to do their work. These mines can only be opened from the surface, and even by this method they cannot be worked to any considerable depth, owing to the high temperature of some of the prospects and the constant escape of noxious gases.

Associated with the deposits of sulphur are beds of gypsum, and also irregular deposits of "alum." Just what the nature of this "alum" may be has not been determined by analysis. These beds usually overlie the sulphur deposits, the alum being sometimes two feet thick, and the gypsum as much as eight feet. Hot springs occur in the same field, which, together with the feeble fumerole at the top of the old crater, bear evidence of the expiring volcanic energy of the region.

Sulphur Deposits at Humboldt House, Nevada.

The sulphur at this locality has been reported as occurring in nearly vertical fissures that are associated with recent basaltic buttes. Careful search was made by the writer, however, for fissures answering these conditions, while examining the surface geology of the Humboldt Valley, without successful results. The only sulphur deposits that could be found in the vicinity, and the only ones known to the people living at Humboldt House, occur in the craters of extinct hot springs. These craters are situated about half a mile southward of Humboldt House, on the open sage-brush desert, and rise to the height of from twenty to fifty feet, as nearly as could be estimated. Nearly all of the cones are weathered and broken down, and all are extinct, the water now rising to the surface for miles around. The outer surface of the cones is composed of calcareous tufa and silicious sinter, forming irregular imbricated sheets that slope away at a low angle from the orifice at the top. The interiors of these structures are filled with crystalline gypsum, that in at least two instances is impregnated with sulphur. One of the cones has been opened by a cut from the side in such a manner as to expose a good section of the material filling the interior, and a few tons of the sulphur and gypsum removed. The percentage of sulphur is small, and the economic importance of the deposit, as shown by the excavation already made, will not warrant the further expenditure of capital. The cone that has been opened is surrounded on all sides by a large deposit of calcareous and silicious material, thus forming a low dome or crater, with a base many times as great in diameter as the height of the deposit.

These cones correspond in all their essential features with the structures that surround hot springs that are still active in various parts of the Great Basin, thus leaving no question as to their origin. They are situated within the basin of Lake Lahontan, and must have been formed and become extinct since the old lake evaporated away.

Sulphur is reported as occurring in the chemically formed deposits that surround Steamboat Springs, situated midway between Carson and Reno, Nevada. The conditions at these springs must be very similar to what existed near Humboldt House, at the time the cones containing the sulphur were formed.

Sulphur is also said to occur in the Sweetwater Mountains, situated on the boundary between California and Nevada, in latitude 38° 30′; the extent and geological relations of these deposits are unknown.

The Rabbit Hole Sulphur Mines.

These mines are located in northwestern Nevada, on the eastern border of the Black Rock Desert, and derive their name from the Rabbit Hole Springs, a few miles to the southward. The hills bordering the Black Rock Desert on the east are mainly of rhyolite, with a narrow band of volcanic tuff along the immediate edge of the desert. These beds of tuff are stratified and evidently water-laid, and are identical with tuff deposits that occur over an immense area in Oregon and Nevada. At the sulphur mines, the tuffs contain angular fragments of volcanic rock and are cemented by opal and other silicious infiltrations since their deposition, so that they now form brittle silicious rocks with pebbles and fragments of older rocks scattered through the mass. In many places these porous tuffs and breccias are richly charged with sulphur, which fills all the interstices of the rock and sometimes lines large cavities with layers of crystals five or six feet in thickness. In the Rabbit Hole district, sulphur has been found in paying quantities for a distance of several miles along the border of the desert, but the distribution is irregular and uncertain, and is always superficial, so far as can be judged by the present openings. As in the Cove Creek mines, the sulphur at

Rabbit Hole has been derived from a deeply-seated source, and deposited from a vaporous condition, in the cooler and higher rocks in which it is now found. Judging from the silicious material that cements the tuffs, it is evident that the porous rocks, in which the sulphur is now found, were penetrated by heated waters bearing silica in solution, previous to the deposition of the sulphur. These mines occur in a narrow north and south belt, along a line of ancient faulting which is one of the great structural features of the region. The association of faults, with sulphur bearing strata of tuff, is here essentially the same as at the Cove Creek mines. At the Rabbit Hole mines, however, no very recent movement of the ancient fault could be determined. This absence of a recent fault-scarp, together with the fact that the mines are now cold and do not give off exhalations of gas or vapor, shows that the solfataric action at this locality has long been extinct.

At all the localities visited, the sulphur has been derived from sources far beneath the surface, from which it has been expelled by heat, and escaped upwards through fissures that were formed along lines of faulting, and has been condensed on the sides of fissures and in the interspaces of the cooler rocks near the surface. Whether the deposition of the sulphur took place by direct sublimation, or by the decomposition of sulphuretted hydrogen, has not been determined. The date at which the sulphur was introduced into the rocks, where we now find it, is in all cases very recent, and at the Cove Creek mines the action is still in progress.

Work at the Rabbit Hole mines is now being carried forward by a day-shift of seventeen men, the production of sulphur being about six tons per day. The value of the sulphur produced is about forty-five dollars per ton in San Francisco. The sulphur, after being mined and assorted, is placed in upright cast-iron retorts, having a general resemblance to the common form of blast furnace, with a capacity of about two and one-half tons. When the retorts are charged, the opening at the top, through which the sulphur bearing rock is introduced, is closed, and superheated steam admitted at the side. The steam pressure is at first about seventy pounds to the square inch ; but, as the sulphur begins to melt, the pressure is allowed to subside to sixty or perhaps fifty pounds. When the sulphur melts, it passes through a grate and is collected in a kettle beneath the retort, from which it is allowed to flow, in a very liquid brown stream, into a receiving pan with a capacity of about twelve thousand pounds, where impurities that were previously held in suspension are allowed to settle to the bottom. From the receiving pan, the sulphur is run into molds shaped like the frustum of a cone, each of which has a capacity of from two hundred to two hundred and fifty pounds. When allowed to stand a few days after cooling, these cylindrical masses break into irregular lumps, in which condition the sulphur is delivered to the refinery at San Francisco.

DISCUSSION.

The PRESIDENT remarked at some length upon Mr. RUSSELL'S paper, giving extended observations of his own in the volcanic rocks of that region.

Remarks were made by several members, and by the PRESIDENT, upon the recent "Forestry Congress," and the great importance of the subjects discussed by that body.

May 29, 1882.

SECTION OF PHYSICS.

The Vice-President, Dr. B. N. MARTIN, in the Chair.

Fifty-seven persons present.

The Secretary exhibited a fresh specimen of the common squid (*Ommastrephes*, sp.), and remarked on the habits, affinities, and geological relations of these animals, and also on the accounts, given by Prof. A. E. VERRILL, of the recent capture of a gigantic specimen on the coast of Newfoundland. Prof. VERRILL reports the length of this individual as nine feet for the body and thirty-five feet for the entire extent, to the ends of the long "arms."

He also referred in the same connection to a story told in a work called "Ocean Wonders" (Appleton & Co., N. Y., 1879), wherein it is asserted that the author, while at Bermuda, had seen an Octopus leave the water and climb a cliff 200 feet high, in pursuit of a red crab (!). This absurd story, so impossible in view of the habits, organization and locomotive apparatus of the cephalopods, is most fully disposed of by a Bermuda naturalist, Mr. J. MATTHEW JONES, as follows:

1. There is no cliff of any kind in Bermuda that is 200 feet high.

2. There is no crab on the Bermuda shores, having a red carapace, during life.

3. The only species of Octopus known at Bermuda never leaves the water.

A paper, by Mr. GEO. N. LAWRENCE, was read by title as follows:

DESCRIPTION OF TWO NEW SPECIES OF BIRDS OF THE FAMILIES COLUMBIDÆ AND FORMICARIDÆ.

This paper appears in the Annals, Vol. II., No. 11.

Dr. ELSBERG nominated as a Corresponding Member the lecturer for April last, Chevalier ERNST VON HESSE-WARTTEGG, who was thereupon elected unanimously.

Mr. ROMYN HITCHCOCK then read the following paper, illustrated with a large number of experiments:

RECENT ADVANCES IN PHOTOGRAPHY.

Perhaps it is well to introduce the subject before the Academy in a practical rather than a theoretical form, since photography is a branch of scientific study to which our men of science generally have given but little attention. Yet it possesses great interest for the chemist, who has yet to determine the decompositions which an actinic ray produces in compounds sensitive to light. It affords the student of molecular physics a wide field for investigation. A more profound knowledge of the action of light upon the photographic film will doubtless lead to a deeper insight into the nature of the actinic force itself. Already the photographic plate has enabled us to study the solar spectrum far beyond its visible limits at either end; for not only has it enabled us to record and establish the exact position of the Fraunhofer lines beyond the violet, but, more recently, the spectrum of the red and ultra red has also been portrayed by an ingenious application of well-known facts.

There are three compounds of silver which may be used in the preparation of dry plates, the chloride, the iodide and the bromide. These compounds, being insoluble in water, can be formed by adding a corresponding salt of an alkali to a solution of silver nitrate. They are then precipitated in very minute particles. In each of these three test tubes I place a few drops of a solution of nitrate of silver. To the first one I add a chloride, which gives me a pure white precipitate of chloride of silver. To the second I add a bromide, to the third iodide. The silver bromide is yellow, the iodide is slightly so.

A brief exposure to the light of day changes the color of these salts, and it is this peculiarity which makes them valuable for photography. Years ago, when photography was in its infancy, the problem was to obtain these compounds in a sufficiently sensitive condition to be useful. If we could collect the fine particles, which are suspended in the water in those tubes, before the light has affected them, spread them in a perfectly uniform layer over a sheet of paper or upon a glass plate, and then allow an image to fall upon it in the camera, wherever the light strikes it the color would be changed, and thus a perfect photograph of the object would be produced. But such a photograph would fade if brought out into the light; besides, it would not be very intense. It is necessary, therefore, to devise some method by which the change produced by the light can be strengthened, and then fixed. In practice, the sensitive compound is obtained upon a glass plate in one of two ways; either by coating the plate with a film of some substance that is permeable to fluids, such as collodion containing a bromide or an iodide, and then dipping the plate thus coated into a bath of silver nitrate, whereby the silver bromide or iodide is formed within the pores of the collodion; or else by precipitating the silver compound in a solution of collodion, gelatin or other medium, in such a manner that the particles will be held in suspension in a state of minute division. By the latter process a so-called emulsion is formed, which is poured over a plate and allowed to dry before use. The causes which affect the sensitiveness of the bromide are still very obscure. It is probable that this is controlled by the physical conditions under which it is formed; in other words, the size of the particles of bromide in the emulsion. The smaller the particles, the more sensitive they are. Yet it seems possible to increase the sensitiveness of an emulsion, by causing the minute particles to become mechanically aggregated into larger masses. At least, this is the explanation suggested by the able experimentalist, Captain Abney, to account for the greater sensitiveness of a gelatin emulsion after boiling. This aggregation of the particles cannot in any wise affect the sensitiveness of the constituent molecules; but, if we can understand how it causes the film to be more sensitive, we will gain an insight into a molecular change which may be said to lie as the foundation of the process of strengthening the image, which is the process commonly known as development.

It has been stated that a perfectly uniform layer of the sensitive silver salt upon a plate would show an image after exposure in the camera. This image results from the decomposition of the sensitive salt into a sub-bromide, sub-iodide or sub-chloride, as the case may be, the bromine, iodine or chlorine being set free; thus $2\ (Ag\ Br) = Ag_2Br + Br$. The change of color, resulting from a short exposure in the camera, is not great; but it is possible to so prepare a plate that the chemical change produced by light in a fractional part of a second suffices to produce an image. Under such circumstances the chemical change must be very superficial, and the decomposition too slight for the eye to detect. Hence, after a plate is properly exposed in the camera, no image is visible upon it. To make the image visible, it must be strengthened or developed.

Before describing the process of development, I will illustrate the process of making an emulsion of silver bromide for the dry-plate process. Since the only essential part of this process is the suspension of minute particles of bromide of silver in a suitable fluid, which will dry and form a film upon a plate, we might precipitate the bromide as we did a few moments ago, only in a dark room, and rub it up in a mortar with a solution of gelatin or gum arabic, until a fine, milk-like emulsion is formed. A better method, however, and the one usually followed, I propose to carry out before you now. But first I must explain, that, unless the silver salt can be protected from the action of light, the process must be carried on in a room lighted only by a red light. Without spending any time to explain the reason, I will simply state that potassic bichromate prevents the action of light upon the silver salt, and it is therefore possible to prepare an emulsion in daylight, if this compound is used. After the emulsion is made, the bichromate can be removed by washing in a dark room, when the mixture becomes sensitive to light. I now wish to prepare a gelatin emulsion of silver bromide containing some iodide. [Emulsion prepared.]

After the plate has been exposed in the camera, the image is developed by any one of several methods; but all of them depend upon the fact that, in the presence of what chemists designate as reducing agents —substances which greedily absorb oxygen—a salt of silver is decomposed with the deposition of metallic silver. When such a reducing agent is caused to flow over the plate, the reducing action is most powerful at those places where the light has acted upon the sensitive silver salt and decomposed it. Therefore at such points metallic silver is deposited in very minute, black particles, and, as these increase in quantity, the image becomes visible, acquires density, and details are faithfully brought out.

We can readily illustrate the action of the developer by an experiment. Here is a quantity of silver bromide, which has been precipitated and exposed to sunlight. I have here another precipitate of the same compound, which has been protected from the light. To each of these I will add a developing solution, and you will see the rapidity with which the silver is reduced in one case, and how much more slowly it changes in the other. [Experiment made.] Precisely the same effect is produced in developing the invisible image on the exposed plate. I will now develop a plate which was exposed in my camera, one week ago to-day. It is a stereoscopic view of a modern windmill, which is to be found just above High Bridge. The developer to be used is a mixture of ferrous sulphate, or green vitriol, as it is called, with potassic oxalate, containing some potassium bromide. By mixing the two solutions first mentioned, a solution of ferrous oxalate is obtained, which is the active agent in effecting the reduction, the bromide of potassium being a restrainer—preventing the too rapid and too general reduction of the silver salt. Those who are familiar with photographic process will keep in mind the fact that in developing dry plates, all the silver salt is in the film, while, in the wet plate process, it is customary to mix some silver nitrate with the developer and flood the plate with it. In the case of dry plates the fingers are not soiled during this process, while with wet plates they are sure to be blackened by the silver. [Plate developed.]

The time is so limited that I cannot discuss and explain the chemical process of developing a picture as fully as I would wish. I am quite sure that if we were to spend the entire evening in considering this single operation, there would be no lack of interest on the part of this audience. In studying the process of development, explaining how the invisible image is intensified and brought out in all its details, we are dealing with chemical changes which are so slight as to almost baffle our efforts to detect them. The light acts upon the molecules of the the silver salt in the plate, perhaps only the $\frac{1}{10000}$ part of a second of time; but that is enough to overcome, or in some way to weaken, the force which binds together the constituent atoms. When the developing solution is applied, each particle of silver salt that has been thus changed, acts, we may say, as a nucleus to start the action of the developer. The tendency of the latter, as already stated, is to reduce any silver salt that may be present; but if a soluble bromide, such as potassium bromide, be present in sufficient quantity, this tendency is restrained, and no reduction will take place, unless the action is started by the partially decomposed silver salt. The balance of the chemical forces is so perfect in a well-made developer, that wherever there is a molecule of silver bromide on the plate which the light has affected, there decomposition takes place and black metallic silver is deposited, while all the rest of the plate remains white. Thus every line and every shadow and half-tint in an object is faithfully reproduced in the photograph.

After development there remains upon the plate a quantity of unchanged bromide of silver, which must be removed or the light would act upon it, and destroy the picture. The picture must, therefore, be fixed by dissolving the unchanged silver salt in sodic hyposulphite. [Plate fixed.]

In the short account that has been given of the preparation and development of dry plates, no allusion has been made to many questions of great theoretical interest, which I hope to make the subject of a future article. It has seemed best to confine this article to the strictly practical part of the subject; and I now wish to speak more particularly of the advantages of the dry-plate process, not for the photographer in business, but for the traveller and explorer, the naturalist and the student in various branches of science.

The great advantage of the process for all these purposes is to be found in the sensitive plates. They can be purchased ready for use in the camera, and will remain good for any length of time. They may be carried across the continent, exposed in a camera on the top of a mountain hundreds of miles from civilization, or in the interior of an unexplored country, then packed away in light, tight boxes, and the pictures developed months afterward in this city. In this way the geological and topographical features of a country may be accurately reproduced on paper, or, by means of glass positives, thrown upon a screen for the illustration of a lecture. The botanist may photograph a rare plant in bloom in distant lands, and the traveller in Central Africa, for instance, may portray the features of the natives he finds, with far more truthfulness than with pencil and brush.

In the laboratory, the student of physics will find many uses for photography. Already, it has been applied to the study of spectra, with great advantage, and lately the electric spark has been photographed, with an exposure, it is said, of only $\frac{1}{140000}$ of a second.

[The method of making instantaneous pictures was then described, and the apparatus was exhibited. After the Academy adjourned, the process of making positives on glass for use in a lantern was illustrated by placing a negative over a sensitized plate in a deep printing-frame, and exposing it to the light of an argand lamp for about ten seconds, after which the picture was developed and fixed in the usual way.]

June 5, 1882.

Regular Business Meeting.

The President, Dr. J. S. Newberry, in the Chair.

Forty-five persons present.

The report of the Council was read, recommending

1. The election of the following persons, previously nominated as Resident Members:

J. K. Funk, W. H. Mead,
Howard Wainwright, Alexander Warner.

2. That when the Academy adjourns, it shall be to October 2.

The four persons named were unanimously elected, and the recommendation for the usual summer adjournment was agreed to.

The President showed teeth of *Carcharodon*, measuring five inches by six, from the tertiary "Phosphate beds" of South Carolina. This is about the maximum size ever known for fossil shark-teeth. The modern "white shark" is some five feet long and if the proportion was the same between the size of the teeth and the whole body in the ancient *Carcharodon*, its size must have been fully fifty feet. It is noteworthy that very large teeth of similar character, but in quite a fresh condition, were dredged up in the depths of the Pacific by the "Challenger" party; which fact would indicate that this species, or one closely akin to it, had survived in the deep waters, at least until quite recently.

He also exhibited an ingot of aluminium, two inches by six, obtained by a new process, at much lower rates than had heretofore been possible, and remarked upon the many important uses for aluminium, if its cost could be reduced.

The following papers, by Mr. THOMAS BLAND, were read by title:

I. DESCRIPTION OF TWO NEW SPECIES OF ZONITES FROM TENNESSEE.

II. NOTES ON THE DISTRIBUTION OF GENERA OF TERRESTRIAL MOLLUSKS IN THE WEST INDIES.

Dr. WESLEY MILLER read a paper entitled:

THE PREVENTION OF TUBERCULAR DISEASE IN MEN AND ANIMALS BY VACCINATION.

He discussed the general theory of inoculation and vaccination, and referred to experiments made by himself, and to be further carried on, as to the reduction of virulence attainable by artificial propagation of virus through many generations, in the bodies of domestic animals.

Dr. N. L. BRITTON read the following paper:

ON SOME LARGE POT-HOLES, NEAR WILLIAMSBRIDGE, N. Y.

The "pot-holes" which I shall attempt to describe were first brought to my notice by the late Prof. A. WOOD. They are located on the western bank of the Bronx River, about midway between Bronxdale and Williamsbridge, Westchester County, New York. They are near the western end of a now dismantled and impassable bridge, with stone abutments, and in the northern part of a hemlock grove which fringes the stream for about a mile below. It is one of the most picturesque spots in the vicinity of New York City, and a walk along the little river from Bronxdale to Williamsbridge is always enjoyable.

The Bronx "River," as it is called, though the term gives it an importance which it does not possess, is a stream about 40 to 50 feet wide, rising in Westchester County, and discharging its waters into Long Island Sound, nearly opposite College Point.

It occupies, however, the bottom of a valley, which, at Williamsbridge, must be at least half a mile wide, probably more, and two hundred feet deep below the summits of the hills which bound it to the east and west. This great depression extends northwardly with the river, but I have not studied it any further north than White Plains, where it is quite broad. At a point about three-fourths of a mile below the Williamsbridge station of the Harlem Railroad, this valley is somewhat narrowed, and much interrupted by a ridge of rock running parallel with the present course of the stream, viz., very nearly north and south. The Bronx flows through a narrow gorge cut out of this rock. It is near the northern end of this ridge where the pot-holes under consideration are situated. Leaving the train at Williamsbridge, and ascending the stream, we pass through a stretch of swampy ground of considerable botanical interest, it being the only known habitat about New York for *Arisæma Dracontium*, the "green dragon," we pass the old bridge before mentioned, and enter the grove of hemlock. The first pot-hole to be observed is quite imperfect, only a portion of the western side now remaining, the rest having been broken away. It bears S. 50° W. from the western end of the bridge, at a distance of 76 feet. The bottom of the pot is about 18 feet above the present level of the Bronx at this point, but this is less than the natural height would be, as the water is backed up by a dam half a mile below. Measurements indicate that the total depth of the hole must have been about nine feet, and at half its height the diameter not less than ten feet. This must, however, have very rapidly decreased towards the bottom.

Proceeding 136 feet south from the bridge, and then up the rocks to a point 63 feet from the river bank, the second pot will be found. This is much more perfect, and is quite a noticeable object. The bottom of this one is twenty or twenty-two feet above the present water level. The hole is oval in section, about four-fifths of the original outline still remaining, only the outer (the eastern) end being broken away. Its dimensions are as follows:

Total indicated depth, 10 feet.

Depth of nearly perfect lower part, 4′ 6″.

Depth of entire basin at the bottom, 10″.

Shortest diameter, 5′.

Original longer diameter probably about 6′.

Distance from back to broken face, 4′ 7″.

The lower part of this pot is very well preserved; the bottom and sides are very highly smoothed, indeed quite polished. The upper portion, where the wear began, is now represented only by a portion of the rock surface about 5′ high and 2′ long, which is concave and smooth.

Some fifty feet southwest of this hole, and fifteen feet above it, there are two other vertical pieces of rock with smoothed and somewhat concave surfaces, which, perhaps, may be remains of others, but they are too imperfect to warrant any description.

The rock, in which these pot-holes are situated, is a compact fine-grained gneiss, with black mica. It is very much broken up by horizontal and vertical cleavage planes. There are not very many loose blocks, however, these having been carried away to the south by the glacier of the ice period. The natural strike of the strata in the vicinity is S. about 18° W. The dip is nearly vertical, being in the neighborhood of 85° N. W.

The history of the formation of these holes may be briefly outlined as follows: that, in pre-glacial times, the valley through which the Bronx now flows was occupied by a large stream, which was expanded into a broad and deep comparatively slow-moving body of water, above the point where the holes are now situated; but, at and below this point, it became a rapid, turbulent and shallow river, whose level, as shown by the position of the holes, must have been at least thirty feet above that of the present one; that the holes were produced, as they have been shown to be in other localities, by the grinding action of some harder stone on the gneiss rock, this stone being kept in a whirling motion by an eddy in the current. During the ice period the valley was deepened, and the narrow gorge, through which the waters of the Bronx now pass from below Williamsbridge to Bronxdale, was excavated, the ice sheet having carried the debris southwardly and deposited it on the terminal moraine running through Long Island. I am informed by Prof. J. D. HYATT that there are two other pot-holes, rather imperfectly preserved, near the village of West Farms, about two miles south of those described, in the same valley.

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